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Identifying Characteristics of Expert Elementary School Technology Integration Teachers - A Cognitive Task Analysis

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IDENTIFYING CHARACTERISTICS OF EXPERT ELEMENTARY SCHOOL TECHNOLOGY INTEGRATION TEACHERS - A CONGNITVE TASK ANALYSIS

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Abstract

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In all domains, certain individuals consistently perform better than their peers. In ill-structured domains such as education, the identification of experts can be difficult. This is especially true when considering technology integration experts (TIEs). In order to be a TIE, one must be an expert in content knowledge, pedagogy, and instructional technology. Systematically identifying and studying TIEs could provide characteristics consistent with expert performance.

Typically, it takes 1,000 hours, or ten years, of practice to acquire expertise. In domains such as education, the acquisition of expertise can happen sooner. Acquiring expertise can be further hastened by deliberate practice. Not all practice improves performance. To improve performance, activities to improve performance should be carefully planned.

This study compared the cognitive decisions made by TIEs while planning technology-rich lessons to four novice teachers using a cognitive task analysis (CTA) methodology. This research followed a streamlined version of CTA, applied cognitive task analysis (ACTA). According to this study, the identified characteristics of expert performance were using technology to increase student and teacher collaboration, plan student product prior to technology use, plan each lesson on a macro and micro level, model for students and differentiate instruction.

Based on the findings of this study, improvements to teacher preparation programs and professional development could be made. By using the cognitive decisions TIEs make, novice teachers could practice skills they currently lack, thus improving their performance.

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CHAPTER 1

INTRODUCTION

Every discipline has experts. These are the people that have characteristics, skills, and knowledge that distinguish them from novices (Ericsson, 2006). They continually perform at a level others in their domain cannot achieve. These are the individuals sought out when expert performance is required or desired.

Expertise in one domain does not necessarily mean expertise in another domain. Instead, expertise is typically limited to a specific, single domain (Chi, 2006). When a domain has multiple specialties, such as in medicine or education, a person may be an expert in one domain, but not necessarily an expert in others. For example, a teacher may be an expert in content, but not an expert in pedagogy or technology.

Research has been conducted in education to define general education expertise. Berliner (1988) has identified five different categories or stages of teacher expertise (novice, advanced beginner, competent teacher, proficient teacher, and expert teacher). Common characteristics of each category allow a teacher to be placed in one of these categories based on observing their teaching or planning.

In general, gaining expertise can occur through acquisition or inheritance (Ericsson, Roring, & Nandagopal, 2007). In athletics and intelligence, for example, some researchers believe expertise may be inherited. In other domains, some researchers believe expertise may be obtained through education and experience.

In some domains, experts are consistently able to obtain a high level of performance, such as in chess (Ericsson, 2006). In many domains, especially when a test for expertise is absent, the identification of an expert is much more challenging. The identification of expertise frequently comes through the opinions of peers in fields where the identification of expertise is difficult, such as in education (Ericsson, 2006).

The current research reveals that researchers seem reluctant or unable to provide a concise definition of a technology integration expert (TIE). Instead, researchers have identified general characteristics that may be associated with a TIE. According to Meskill, Mossop, DiAngelo, and Pasquale (2002), some of these qualities include:

> the relationship between lesson plans and teachers' implementation of them (Allwright & Bailey, 1991; Bailey, 1996; Peterson & Clark, 1978; Richards & Crookes, 1988), differing abilities as regards moment-by-moment decision making (Leinhardt & Greeno, 1986), awareness and accommodation of learners as individuals (Johnson, 1996; Westerman, 1991), ability to shift content on the fly (Freeman, 1989), the number and quality of instructional patterns and routines in their repertoire (Johnson, 1992), and the degree to which planning is undertaken at a macro or micro level (Nunan, 1992,1996). (p. 46)

Although these characteristics assist in locating TIE, they do not define one. Research has yet to show what skills or tasks can help to improve performance in this domain. Making the assumption that expertise is limited to a specific domain (Chi, 2006) may provide additional insight on the difficulties of being a TIE.

According to Mishra and Koehler (2006), successful technology integration requires careful consideration of three distinct domains; content, pedagogy, and technology. Considering their TPACK framework, Mishra and Koehler (2006) suggests a teacher that successfully integrates technology in all three domains of TPACK will be successful. However, since expertise is typically limited to a specific domain (Chi, 2006), finding teachers skilled in technology integration is challenging. According to the TPACK framework, a TIE needs to be an expert in all three of these domains.

Expertise, regardless of domain, typically occurs in stages or phases (Ericsson, Roring, et al., 2007). In order to gain mastery, an individual must master and move past each stage to the highest stage in that domain. Individuals can be placed on a continuum of expertise through observation or through some kind of assessment. Successful placement of an individual on a continuum will indicate the requisite skills needed to move him or her to the next level on the continuum. This will aid the individual in improving his or her skill, possibly even leading to expertise.

Dunn and Shriner (1999) believe that deliberate practice can improve the performance of educators and may lead to expertise. In order for this improved performance to occur, educators must receive guidance from another individual. However, most teachers receive little or no support after completion of a teacher preparation program.

Most teachers spend about two hours a day, typically in the morning, completing their most strenuous mental activities such as writing about new ideas (Ericsson, Prietula, & Cokely, 2007). Even though teachers spend this time each day, in most instances this large amount of time is not improving performance. Dunn and Shriner (1999) suggest that this time spent daily could be better used. In fact, they believe that a model of deliberate practice that focuses on planning preparation and evaluation could lead to expertise in the amount of time most teachers spend preparing daily. Because no widely agreed upon definition of a TIE exists, the goal of this research was to create a model of expertise in this field using cognitive task analysis. This model could be used by teacher preparation programs and in schools as professional development.

Often, the identification of expertise is completed through social opinion (Ericsson, Roring et al., 2007). This is when the opinion of experts, coworkers, supervisors, or the general public identifies expert performance. In domains where the identification of experts is challenging this method is often used. However, Ericsson, Roring, et al. (2007) offer a warning about the identification of experts through this method. They believe this method may be subjective and opinions of expertise can change through time. A more objective way to identify expertise may prove to be prudent.

The identification of expertise in education through observation may be ineffective (Berliner, 1986). Social opinion may be used to identify experts in education; however the reputation of a teacher may not in fact be accurate.

The identification of experts may be better accomplished through more objective means, such as a rating scale, an independent index, or through placing an individual on a continuum of expertise through observation.

Traditionally, in education, the identification of experts has been more difficult than in many other domains (Berliner, 2001). This may have been because there is no objective measure of expertise in education and because the direct impact of a teacher on a student is difficult to measure. However, through the creation of National Board Certification in 1994, the identification of expert teachers may have become more objective (Ericsson, Roring, et al., 2007). Studies have indicated that the students of

National Board Certified Teachers (NBCT) consistently outperform students of other teachers (Bond, as cited by Berliner, 2004).

The identification of expert teachers through social opinion (Ericsson, Roring et al., 2007) and observation (Berliner, 1986) can contain bias and does not ensure expertise. This study compared the planning of upper elementary teachers who are experts in content, pedagogy, and technology integration to novice teachers who frequently used technology. In order to ensure expertise, only NBCT were used as TIEs. This external certification ensured expertise in both content and pedagogy. To ensure expertise in technology integration for this study, each NBCT completed Van der Heijden's (2000) Measurement of Professional Expertise: Self-assessment questionnaire. In addition, each teacher submitted what they believed to be a quality lesson using technology to the researcher. These lessons where graded on a rubric created by the researcher. Using the aforementioned measures as a way to identify TIEs minimized bias that can be associated with other identification methods.

Identification of Experts

Creating experts to teach in the classroom is critical. Berliner (2004) believes empirical evidence exists that shows teachers identified experts in pedagogy, with a thorough understating of the content they are about to teach, positively affects student achievement. By identifying qualities needed for expertise in the classroom and providing meaningful professional development opportunities for teachers, the number of expert teachers could dramatically increase. This must be accomplished through deliberate practice. However, identifying the requisite tasks needed for expertise in education, specifically in technology integration, are not readily available. Research must be completed showing the traits of experts in technology integration. Successful identification of these traits could lead to a possible blueprint for creating expertise for others in this domain.

In order to identify experts in technology integration, Mirsha and Koehler (2006) suggests the teacher must be proficient in technology, pedagogy, and content. One possible way to find experts in education is by examining how expert teachers plan (Ericsson et al., 2007). Expert teachers plan differently than other teachers, and as Ericsson et al. would suggest, perform deliberate practice on average of 700 hours a year. The identification and duplication of this process may lead to knowledge of what a TIE may look like. This study examined the differences between TIEs and novices when planning lessons using technology based on the research of Ericsson.

The study of expertise in many fields can be challenging. One possible method for studying the cognitive processes of experts in these more challenging fields is by using Cognitive Task Analysis (CTA). CTA allows researchers an opportunity to study cognition in real world settings (Crandall, Klein, & Hoffman, 2006). Using CTA to study expertise is a three step approach.

Phase one is the knowledge elicitation phase. This first phase revolves around identifying the characteristics of the expert's performance. Researchers study the judgments, strategies, knowledge, and skills of the expert. Many methods are available to researchers to study the expert's performance; interviews, self-reports, and observations are just a few.

In the second stage, or the data analysis stage, the expert performance in the first stage is analyzed. The researcher structures the data, identifies findings, and starts to discover meaning in this stage. Some of the tools at the researcher's disposal in this stage include capsulizing incidents, cataloging cues and patterns, identifying themes, and coding data.

Finally, in the knowledge representation stage, the knowledge learned from the expert is represented in some sort of artifact. These artifacts may include narrative formats, chronologies, data organizers, process diagrams, and concept maps. Studying expertise through the use of CTA may ultimately lead to a method of replicating expertise.

The use of CTA began in the early 1980s as a way to study expert performance in the corporate world and in the military. By studying the performance of experts, corporate and military leaders hoped to provide a new way to train individuals and hoped to limit mistakes (Militello & Hoffman, 2008). CTA uses techniques of both quantitative and qualitative research. Crandall et al. (2006) believe CTA to be a perfect blend of both quantitative and qualitative research traditions. They believe the researcher must carefully choose the proper CTA techniques for their research from a large pool of available methods.

CTA served as the basis of the methodology for this study. During this study, participants were asked about both the cognitive decisions they make while planning lessons using technology and the physical actions that occur due to these decisions.

Statement of the Problem

Currently, quality professional development for teachers in technology integration is lacking. Teacher preparation programs may not adequately prepare teachers in technology integration. With this in mind, a great need existed to provide a quality instructional model for teachers in this field. Research exploring the characteristics of TIEs could lead to an improvement in current staff development and in teacher preparation programs. In order to successfully improve current instructional models for teachers to integrate technology, specific characteristics of expert performance in planning lessons with technology must be identified. Although many educators believe that they may be able to identify teachers that are TIEs, no definition seems to be available to help locate these individuals. Instead, we are left with a list of shallow characteristics that may or may not help us to identify an expert. Little research exists to validate these characteristics. In order to successfully identify TIEs, specific characteristics of expert performance needed to be identified. The identification of these characteristics will assist in determining the requisite knowledge required for expertise in this domain. Professional development may be thoughtfully created in order improve teacher performance.

Purpose of the Study

The purpose of this study was to help define common characteristics TIE possess that novice teachers lack. By finding common characteristics, a model of how TIEs prepare lessons using technology was created. This model can be used to train non-expert teachers a way to plan lessons using technology in the same manner TIEs plan.

Significance of Study

Currently, a lack of information on TIEs exists. This study provides a glimpse into the actions and thoughts of four TIEs in the upper elementary classroom. This examination of how these experts planned and the pivotal experiences in their development will add needed details to the research base. This study has established a model for planning lessons using technology, based on expert performance, the domain lacked. This model could lead to meaningful staff development in technology integration. Additionally, this study has identified characteristics consistent with both novices and experts. These characteristics could help to create a pathway for novices to improve their performance and perhaps one day become experts. This data may have the ability to help others improve in the domain of technology integration and may help professional development become more established. Ultimately, the creation of successful professional development in this field could lead to an increase in the amount of experts in this field and could increase the quality of classroom instruction. Ultimately, the increase in student instruction could lead to better student understanding.

Additionally, findings from this study could be used to train preservice teachers in teacher preparation programs. The expert characteristics found in this study could be studied and practiced in these programs as a way to improve technology integration for new teachers.

Finally, the methodology used in this is not typically used in the field of education. This methodology could serve as a template for other researchers in the field of education to establish characteristics of expert performance in needed domains. It may ultimately lead to new findings in education that may otherwise be unobtainable.

Definition of Terms

Cognitive Task Analysis. Cognitive Task Analysis (CTA) attempts to study expert performance with careful attention paid to the work, decisions, and products produced by the expert (Crandall, Klein, et al., 2006). The researcher studies what the experts are paying attention to, strategies used to make decisions or detect problems, and what the expert knows about how the way a process works. CTA has three primary aspects; knowledge elicitation, data analysis, and knowledge representation.

Deliberate Practice. "Deliberate practice involves two kinds of learning: improving the skills you already have and extending the reach and range of your skills (Ericsson, Prietula, et al., 2007, p. 117)." Deliberate practice is when an individual intentionally performs a task in a considerable, specific, and sustained manner on a topic the individual does not currently do well (Ericsson, Prietula, et al., 2007). Deliberate practice may be greatly aided with the help of a coach or mentor. Most expert teachers only devote about two hours per day to their most demanding mental activities. Over the course of a year, this may lead to 700 hours of practice time.

Expertise. According to Ericsson, Prietula, et al. (2007), expertise must pass three tests. First, an expert will consistently perform better than his or her peers. Second, experts will be able to produce concrete results. Finally, an expert can replicate his or her performance and this performance can be measured in a lab. With deliberate practice, it typically takes an individual ten years to obtain expertise in a domain.

National Board Certified Teacher (NBCT). National Board Certification is an advanced national certification that must be renewed every ten years (National Board for Professional Teaching Standards, 2012). It is available on a voluntary basis for most teachers. The certification consists of ten assessments; four portfolio entries that evaluate teaching practice and six constructed response exercises to measure content knowledge. These assessments are reviewed by trained teachers in each content area. The fee to achieve National Board Certification is currently $2,500 plus a $65 application fee. Research indicates that students of National Board Certified Teachers (NBCT) outperform students of non-board certified teachers on standardized tests. In fact, The National Board for Professional Teaching Standards website says over 160 studies suggests NBCT profoundly impact student learning.

Technology Integration Expert (TIE). A technology integration expert (TIE) is a teacher who is in expert in content, pedagogy, and technology integration. For this study, expertise is measured through National Board Certification and Van der Heijden's (2000) Measurement of Professional Expertise: Self-assessment questionnaire. Additionally, potential TIEs submitted a lesson graded by the researcher on a rubric (Appendix C).

TPACK. TPACK is an acronym standing for technological, pedagogical, and content knowledge (Mishra & Koehler, 2006). Earlier work of Schulman (Mishra & Koehler, 2006) theorized two distinct and important parts of teacher knowledge; pedagogy and content knowledge. Mishra & Koehler (2006) have added a third domain to Schulman's work; technology. In order to be a technology integration expert, an individual must be an expert in technology, pedagogy, and content knowledge.

Research Questions

This study closely examined experts in the field of technology integration in the elementary classroom. The completion of this study established characteristics that can be associated with expert performance in this domain. The characteristics discovered in this study may lead us to a better understanding of experiences that lead to expertise in this field and why experts in this field make the decisions they do. This study was designed to answer the following questions:

1. What is the decision-making process technology integration experts use when planning to teach technology-rich lessons?
2. What is the decision-making process novice teachers use when planning to teach technology-rich lessons?
3. How do technology integration experts plan to teach with technology differently than novices?
4. When planning to use technology-rich lessons, what mistakes do novice teachers make that technology integration experts do not?

Limitations

This study was limited by many factors. A total of four subject matter experts and four novices were chosen to participate in this study. This number was chosen because it is consistent with the numbers of experts chosen for CTA studies (Sullivan et al., 2008). However, since no CTA studies were found in this domain, it is uncertain if this number of experts was adequate. If other experts were chosen for this study, the results of it may turn out differently. In order to add credibility to the findings, the expert participants included in this study were chosen different school districts. Finally, since only one researcher is being used for this study, no intercoder reliability will be able to be established, however, findings were shared and checked by each participant to ensure accuracy. Although some research suggests CTA studies may have a high degree of reliability (Militello & Hutton, 1998), few empirical tests of the reliability of CTA studies exist (First, although steps are being taken to minimize this possibility, the success of this study is dependent on accurately identifying qualified experts in this field. Secondly, an assumption is being made that since teachers in the study are National Board Certified, these teachers will in fact be experts in both content and pedagogy).

Delimitations

This study compared expert and novice teachers who frequently use technology in the upper elementary setting only. With this in mind, caution must be used when applying the findings of this study in a middle school or high school settings. Additionally, this study focused only on the planning of technology-rich lessons and did not focus on other aspects of teaching.

Organization of Study

This study is organized into five chapters. Chapter I contains background information on the study, statements of the problem, purpose of the study, significance of the study, definition of important terms, research questions, limitations, delimitations, and implications of the study.

Chapter II serves as a review of the current literature. This chapter defines expertise, provides methods for identifying expertise, discusses metacognition, and explains Cognitive Task Analysis. It also discusses weaknesses in the current literature in this domain. This study will help to fill the gap located in the currently literature.

Chapter III explains the methodology used for this study. Included in this chapter are the research questions, information on participants, the research design and procedures, the data collection process, and the analysis of the results.

Chapter IV discusses the results of this study. Data collected during the study is displayed for the task diagram, knowledge audit, and simulation interview for each expert and novice. In addition, a cognitive demands table was created. Finally, a list of characteristics of expert and novice performance in this domain was created.

Chapter V concludes this study. This chapter summarizes the entire study, discusses the findings, gives conclusions, discusses implications for both P-12 and higher education, and provides recommendations for future research on this topic.

The appendices contain information used to help identify experts for the study and interview protocols for the novices and experts. Appendix A contains the Measurement of Professional Expertise: Self-assessment questionnaire (Van der Heijden, 2000). This instrument was used to identify technology integration expertise. Appendix B is the Open-Ended Screening Questions. These questions helped the researcher identify participants for this study. Appendix C, the Open-Ended Screening Questions Rubric was used to score the questions from Appendix B. Appendix D and Appendix E served as a basis for the task analysis interview. These documents aided the researcher while conducting the task diagram interview with each participant. Appendix F and Appendix G served as a basis for the knowledge audit. These documents aided the researcher while conducting the knowledge audit with each participant. Appendix H and Appendix I served as a basis for simulation interview. These documents aided the researcher while conducting the simulation interview with each participant. Appendix J is the cognitive demands table. Information obtained from the above interviews will be placed in this document.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter reviews the current literature on topics related to this research. The beginning of this chapter focuses on expertise. First, expertise is defined. Then, expertise in education and expertise in education with technology is examined. Various examples of stages and phases of expertise are identified followed by methods of determining an individual's stage. Then, the manner in which individuals become experts is considered. Ways to identify experts, including empirical ways of identifying expertise, is discussed. Expertise in education, types of expertise, metacognition, the creation of expertise in education, the identification of experts in technology integration, and cognitive task analysis completes this chapter. Ultimately, this literature review will show that expertise is typically acquired through experience and purposeful training. Identifying characteristics of expertise could help improve the performance of non-experts.

Defining Expertise

In order to provide an adequate definition of expertise, one must first examine how expertise is acquired. By examining the literature in expertise, two theories of expertise acquisition are most prominent. First, some researchers believe that expertise is a product of experience, often acquired through guided practice (Ericsson, 2006). Other researchers believe experience is not the primary tool used to acquire expertise. Instead, these researchers believe that expertise is an innate talent that is often identified in childhood (Howe, Davidson, & Sloboda, 1998). If in fact expertise can be acquired through experience, a plan to acquire expertise can be devised through careful study.

According to Ericsson (2006), expertise “refers to the characteristics, skills, and knowledge that distinguish experts from novices and less experienced people” (p. 3). By closely examining this definition, one can identify the importance Ericsson places on experience when considering expertise.

According to a study of chess players conducted by Simon and Chase (1973), experience was unquestionably the primary factor in chess expertise. According to Simon and Chase, “there are no instant experts in chess.… There appears not to be on record any case (including Bobby Fischer) where a person has reached grandmaster level with less than about a decade’s intense preoccupation with the game” (1973, p. 402). The research by Simon and Chase in chess has often been coined the ten-year rule and has been transferred to other domains of expertise. As a general rule, many researchers believe the acquisition of expertise in a domain typically takes a decade of practice and experience (Ericsson, 2006). Through practice and experience, researchers such as Simon and Chase (1973) and Ericsson (2006) would argue expertise can be acquired through careful study.

According to Ericsson, Prietula et al. (2007), in order to identify real expertise, three conditions must be satisfied. “First, it must lead to performance that is consistently superior to that of the expert’s peers. Second, real expertise produces concrete results…. Finally, true expertise can be replicated and measured in the lab” (Ericsson, Prietula, et al., 2007, p. 117).

Other researchers believe expertise is acquired through innate talent and can often be seen from childhood. Howe et al. (1998) support their claims of expertise gained through innate talent by providing examples of children acquiring advanced skills early in life, rare gifts such as perfect pitch that would otherwise be difficult to explain, biological correlations between certain skills and abilities, and examples of mentally handicapped or autistic people who possess advanced skills with limited learning experiences (Howe et al., 1998).

Seemingly, no widely agreed upon single definition of expertise exists. Van der Heijden believes “the research on professional expertise is in its infancy” (2000, p. 10). Perhaps part of the reason for the difficulty in defining expertise is that it can look quite different in various domains. Typically, expertise is limited to a specific domain, such as education (Chi, 2006).

Expertise in Education

Berliner (2001) finds that expertise in education is consistent with the Chi and Ericsson models; it is typically specific to a single domain and is gained through practice and experience. Typically, it takes a teacher three to five years of experience before he or she is no longer surprised by occurrences in the classroom. To achieve high levels of skills as a teacher usually takes five to seven years (Berliner, 2001). The reduction in time to expertise from the ten year rule may be due to preparation in college and experience as a student (Berliner, 2004). However, acquiring a high level of competence for a teacher is quite contextualized. Moving a teacher to a new school or teaching unfamiliar students may negatively impact his or her performance (Berliner, 2004, p. 202).

Identifying expertise in education is much more challenging than in other fields. Berliner (1991) identifies the following three reasons for this complexity:

> First is the belief that ill-structured domains, such as economics, political science, or pedagogy, expertise is not easily demonstrated. There are no easily agreed

> upon "right moves," as in chess, bridge or during problem solving in physics or mathematics. Second, without tournaments of chess or bridge, or the peer reviewed awards that are granted to the leading physicists and mathematicians, it is hard to identify an expert in a relatively unambiguous manner. Finally, pedagogical knowledge in our society is not valued. Pedagogical knowledge is not seen as sophisticated knowledge because it overlaps with knowledge of childcare, is possessed mostly by woman, held by members whose social-class standing is not high, and it is a form of knowledge thought to resemble common sense so closely that anyone can acquire it rapidly. (p. 146)

In order to identify expertise in education, Berliner (2004) has determined that expert teachers are able to handle repetitive operations with automaticity and routinization. Additionally, Berliner (2004) states:

> expert teachers are more sensitive to the task demands and social situation when solving pedagogical problems; expert teachers are more opportunistic and flexible in their teaching than are novices; expert teachers represent problems in qualitatively different ways than do novices; expert teachers have fast and accurate pattern-recognition capabilities, whereas novices cannot always make sense of what they experience; expert teachers perceive meaningful patterns in the domain in which they are experienced; and although expert teachers may begin to solve problems slower, they bring richer and more personal sources of information to bear on the problem that they are trying to solve. (p. 201)

Expertise in Education Using Technology

As with other domains, using technology in the classroom effectively seems to be a product of expertise. Even novice teachers who receive state of the art training in technology in classroom technologies are typically not comfortable in using them in the classroom (Meskill et al., 2002). According to research from Meskill et al. (2002), experts in using technology in the classroom may currently learn their expertise without any formal technology training.

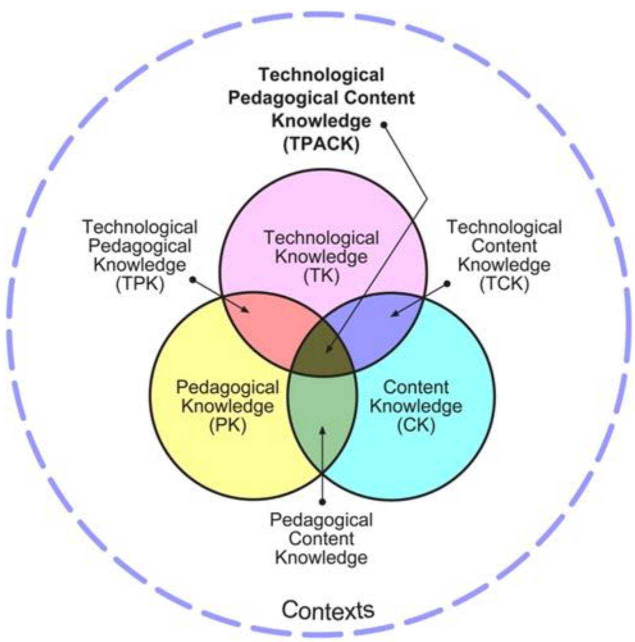

Figure 1. Technological Pedagogical Content Knowledge (TPACK). The seven domains of TPACK. Adapted from Koehler, M (2011). TPACK – Technological Pedagogical and Content Knowledge. Retrieved from: http://www.tpck.org/

Mirsha and Kohler (2006) suggest that three separate domains should be considered when measuring technology in education. Teachers have historically been prepared through teacher education programs on content. A teacher was expected to be an expert in the subject he or she taught. However, until recently, little regard was given to how information was delivered to students. Pedagogy was largely ignored. When using technology to instruct, technology must be carefully considered with both content and pedagogy. Typically, when using technology, many teachers do not consider the factors of content or pedagogy.

Pedagogy, the art of teaching can happen in many forms. For the purposes of this study, differences in pedagogy will not be judged. Potential participants in this study will be deemed as experts in both content and pedagogy if currently national board certified teachers (NBCT). The National Board Certification process determines educators are experts in both content and pedagogy through an extensive certification process. Additionally, in this study, the participants will be evaluated for technology expertise through Van der Heijden’s (2000) expertise instrument. National Board Certification and the Van der Heijden’s instrument will show expertise in content, pedagogy, and technology without the need to evaluate it.

Building on the work of Shulman’s Pedagogical Content Knowledge, Mirsha and Koehler (2006) have created a framework for considering educational technology called TPACK. TPACK is an acronym for technological, pedagogical, and content knowledge. As with Shulman’s work, TPACK contains the domains of pedagogical knowledge (PK) and content knowledge (CK). However, TPACK adds a third domain absent from Schulman’s work; technology knowledge (TK).

The three domains of TPACK show the requisite knowledge needed for teachers in the classroom. The following paragraphs provide a brief overview of the seven domains of TPACK.

Content knowledge is one of the domains created by Schulman. In this domain, the subject matter of the class is considered. Teachers must clearly understand the material they are teaching. Traditionally, teacher education programs were focused on this domain.

Pedagogical knowledge is the second domain created by Schulman. This domain focuses on the manner used to teach the content. This may include lesson plans, student evaluation, and delivery method.

Technology knowledge is the knowledge to understand the technology being used in the classroom. The technology may be low level technology such as books, paper, and a blackboard or more advanced technologies such as the Internet and computer software.

Combing content knowledge and pedagogical knowledge creates the domain of pedagogical content knowledge (PCK). In PCK, content knowledge must be merged with pedagogical knowledge in a simultaneous manner to improve the teaching process.

Content knowledge combined with technology knowledge creates the domain of technological content knowledge (TCK). This domain focuses on the technology available to aid in the acquisition of content. With new technologies being created rapidly, the ability to represent content in new, unique ways continues to grow.

Technological pedagogical knowledge (TPK) is the combination of technological and pedagogical knowledge. In this domain, one possesses the technological knowledge of how to use new technology while considering a useful pedagogy. Technologies in this domain can be used for efficiency such as for record keeping or grading or as a teaching tool such as a chat room or a WebQuest.

Combing the six previous domains creates the technological pedagogical content knowledge domain, or TPACK. In this domain, a technology integration expert would be able to successfully negotiate all of the prior six domains simultaneously.

According to TPACK (Mirsha & Koehler, 2006), an individual will need to be an expert in all of the domains in order to be a technology integration expert (TIE). Seemingly, this multi-domain phenomenon is not limited to just technology integration by teachers. For example, consider medicine. In this field, expertise "requires mastery of a diversity of knowledge and skills – motor, cognitive, and interpersonal – which make it unlike many other fields of expertise, such as chess, bridge, computer programming, or gymnastics" (Norman, Eva, Brooks, & Hamstra, 2006, p. 339). In addition to the multiple domains to master in medicine, individuals who are experts must stay current with new medical advances. Sometimes, as physicians gain experience, previous training can be forgotten. In fact, "older physicians consistently perform less well on knowledge tests than their younger colleagues, a trend that is more or less linear from the point of graduation" (Norman et al., 2006, p. 349). This may lead to difficulties in diagnosing uncommon ailments (Ericsson, Roring, et al., 2007). This seems consistent with teaching, as standardized test scores of their students almost always decline in the final few years of a teacher's career (Ericsson et al., 2007).

Recent research on TPACK has brought up concerns when using this theory as an evaluation tool. In fact, the authors of TPACK have indicated a "wicked problem" using TPACK exists. Solving current problems in TPACK may actually cause other problems to be found. Currently, little is known about how teachers develop TPACK, the essential experiences needed to gain competencies in TPACK, and what effect new technologies have on TPACK (Ness, 2011). Perhaps more importantly, an adequate way to assess teacher's current TPACK level does not exist. This study has identified experiences experts identified as being critical in developing their skills; something TPACK does not address.

Stages or Phases of Expertise

According to Ericsson, Roring, et al., (2007), "for many domains, skill improvement may be represented as a sequence of states. Each change in performance, such as a transition from one state, S[i], to another state, S {i+1}, must reflect some change in cognitive or physiological mechanisms" (p. 14). Stated differently, in most domains, a set of stages or phases of expertise exist. "The acquisition of most types of expert performance can be viewed as the sequential mastery of increasingly higher levels of performance through the acquisition of more complex and refined cognitive mechanisms" (Ericsson, Roring, et al., 2007, p. 24). Individuals can be placed in these phases by examining his or her performance with the characteristics associated with each phase. Requisite characteristics needed for achievement of the next higher phase can then be achieve through purposeful practice (Ericsson, Krampe, & Tesch-Romer, 1993) or experience (Ericsson, Roring, et al., 2007).

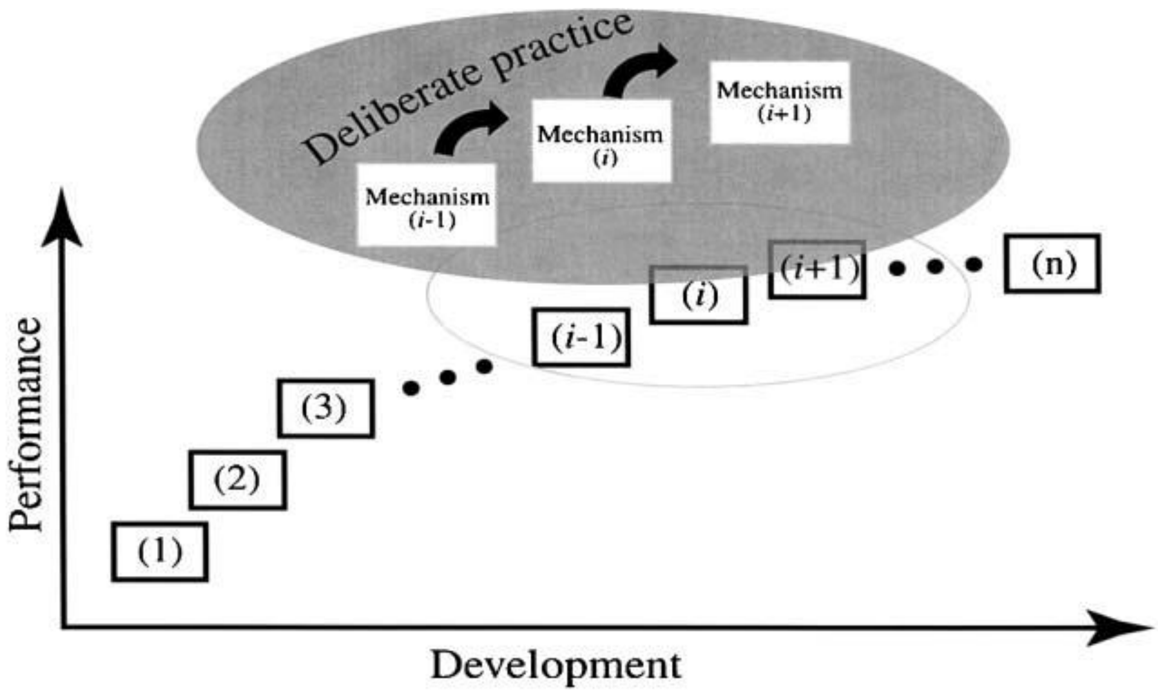

Figure 2. A schematic illustration of the acquisition of expert performance as a series of states with mechanisms for monitoring and guiding future improvements of specific aspects of performance. (Adapted from Starkes & Ericsson (Eds), 2003, Expert performance in sport: recent advances in research on sport expertise, p. 70. Copyright 2003 Human Kinetics.)

Chi (2006) has adapted a general proficiency scale from Hoffman that contains six distinct categories (as well as a category for a person who is totally ignorant of a domain). First, individuals enter the *novice* stage in which the individual has had minimal exposure to the domain. In the second stage, or initiate, the individual has just started instruction in their domain. Next, an individual enters the *apprentice* stage. During this stage, the individual is going through a program of instruction that increases his or her knowledge beyond an introductory level. The fourth stage is the *journeyman* stage. In the journeyman stage, an individual has achieved a level of competence that allows the individual to perform in the domain unsupervised. Next, an individual enters the *expert* phase. Experts in a domain are highly respected by peers and possess great knowledge in sub domains. Finally, an individual enters the *master* phase. In this phase, the individual has the ability to teach others. Additionally, this person is a member of an elite group of experts. In this study, the decision making process of individuals in the novice stage will be compared to the decision making process of master TIEs.

Glaser has created a three-stage theory for the acquisition of expertise (Berliner, 2001). In the first stage, the *externally supported* stage, the individual is just starting to get acquainted in the domain. A coach or teacher guides the learner through this process. The second phase is called the *transitional phase*. During the transitional phase, learning for the individual is scaffolded. In this phase, the individual uses guided practice and self-monitoring and self-regulation begin to take place. In the final phase, or the *self-regulatory* phase, the expert takes entire control of the learning environment. Berliner (2001) believes that this model is more relevant in domains where one performs individually such as in chess or ice skating and less plausible in domains where "social constraints on behavior are stronger, as in learning to teach or to be a nurse" (Berliner, 2001, p. 19). However, Berliner does not believe this model is adequate for education.

Stages or Phases of Expertise in Education

In education, Berliner (1988) believes the acquisition of expertise occurs in five phases. As with many other disciplines, the amount of time an individual spends in each phase can vary widely. Many teachers may have characteristics of more than one phase simultaneously. As Chi (2006) believes, Berliner (1988) points out that expertise appears to be highly contextualized.

Teachers begin in the *novice* phase. During this initial phase, which typically occurs during a teacher preparation program, very little is expected of the teacher. Students are taught vocabulary terms such as higher-order questions and learning disabled. Simple decontextualized rules such “give praise for right answers” (Berliner, 1998) are taught.

The second phase, or the *advanced beginner* phase, can be characterized by adding some context to the initial phase based on some experience (Berliner, 1998). Berliner refers to this as strategic knowledge. Students learn when to use certain rules and when to ignore them.

Stage three, or the *competent* stage, is the phase that Berliner (1988) believes all pre-service teachers should achieve before graduation. In this stage, competent performers “make conscious choices about what they are going to do. They set priorities and decide on plans” (Berliner, 1988, p. 4). Teachers in this stage are able to decide when a certain topic has been successfully covered or when it has not. The novice teachers participating in this study would likely be placed in this stage.

During the fourth phase, or the *prominent* stage, Berliner (1988) believes that “intuition or know-how becomes prominent” (p. 4). Teachers in this phase have the ability to see things more holistically. They begin to notice patterns that occur in the classroom and are able to alter classroom routines accordingly.

In the *expert* stage, Berliner (1988) categorizes teachers as arational. Although still intuitive, expert teachers “seem to sense in nonanalytic, nondeliberate ways the appropriate response to make” (Berliner, 1988, p. 5). These teachers are fluid performers and typically do things in the classroom that work well. The TIEs in this study would be placed in this stage.

The above stages are general in nature and do not specifically address how technology integration experts acquire their knowledge. Although these models are beneficial to researchers studying expertise in many domains, more specifics about how technology integration experts acquire their expertise are needed. Additionally, these models are dated. Using a new methodology may prove useful. Gaining more specific information on the acquisition of expertise in this domain could eventually lead to a model for duplicating it.

Expertise in medicine and technology integration may have many things in common. First, unlike many other domains, expert physicians must be experts in multiple domains (Norman et al. 2006, p. 339). Mirsha and Koehler (2006) would argue the same is true in technology integration. This may be the reason defining an expert in both medicine and technology integration is so difficult. Another similarity is the declining performance of experts in each field. In medicine, physicians seem to lose knowledge learned in preparation courses as their careers progress (Norman et al., 2006; Ericsson et al., 2007). Similarly, in the final few years a teacher works, standardized test scores of his or her students almost always decline as compared to previous years (Ericsson et al., 2007).

Spiro et at al. (1991) agree with these researchers. They believe that both instructional technology and medicine both belong to ill-structured domains. An ill-structured domain is defined as follows:

> 1) each case or example of knowledge application typically involves the simultaneous interactive involvement of multiple, wide-application conceptual structures (multiple schemas, perspectives, organizational principles, and so on), each of which is individually complex (i.e., the domain involves concept- and case-complexity); and
>
> 2) the pattern of conceptual incidence and interaction varies substantially across cases nominally of the same type (i.e., the domain involves across-case irregularity (Spiro et al., 1991, p. 4)

Learning leading towards expertise in ill-structured domains and well-structured domains can be quite different. In many ways, strategies for learning in these different domains are opposite (Spiro et al., 1991). An example of this would be compartmentalization of knowledge components. This is a strategy which would be effective in well-structured domains, however, is much less effective in ill-structured domains. Because ill-structured domains are quite intertwined, examining part of a domain in isolation will not typically be effective. This is yet another example of the difficulties in examining ill-structured domains. Additionally, a focus on general principals and single unifying examples are best when used in well-structured domains.

Spiro et al. (1991) suggest using multiple knowledge representations as a way to aid advanced learning in ill-structured domains. Unlike well-structured domains, ill-structured domains embody knowledge used in many different ways that cannot be anticipated in advance. Oversimplification is typically the largest hurdle in acquiring advanced knowledge in ill-structured domains. Multiple perspectives must be used in ill-structured domains in order to avoid oversimplification.

Methods of Determining an Individual's Stage

Many methods exist for determining the current stage of expertise of an individual. The method of determination often varies based on the domain. Often, individuals display characteristics of multiple stages, thus complicating the identification of a single stage.

In some cases, the use of an instrument can aid in the identification of expertise. Van der Heijden (2000) created an instrument (see Appendix A) that would help identify expertise in any domain. Through an examination of the relevant literature, she has concluded expertise is a multi-dimensional concept in which an expert must possess three different kinds of knowledge; declarative knowledge (the knowledge of knowing that), procedural knowledge (the knowledge of knowing how) and conditional knowledge (the knowledge of knowing when and where or under what conditions). Van der Heijden (2000) also adds a fourth and fifth dimension required for expertise. The fourth dimension, acquiring social recognition, requires an individual to be respected by knowledgeable people of the organization. The final and fifth dimension has been coined growth and flexibility. Individuals capable of acquiring expertise within adjacent fields or different fields can be called "flexperts" (Van der Heijden, 2000).

The Measurement of Professional Expertise: Self-assessment questionnaire by Van der Heijden (see Appendix A) was created on the belief that "some characteristics of expert performance are valid regardless of the domain of expertise of a certain profession" (2000, p. 28). The instrument takes the five dimensions listed above and places them in a self-reporting questionnaire with five parts; one part for each of the five types of expert knowledge. The author believes this "instrument may be useful as a means of identifying professional expertise and expert performance and finding individuals who need support to improve and excel further" (Van der Heijden, 2000, p. 30). In other words, this instrument may not just be useful in finding experts, but may also be used to find individuals across a broad range of abilities.

Although intended to be a self-reporting questionnaire, Van der Heijden (2000) had 558 employees self-report and 454 supervisors rate their employees on the five different domains contained in the instrument; knowledge ($\alpha = 0.83$ for employees, $\alpha = 0.93$ for supervisors), meta-cognition ($\alpha = 0.86$ for employees, $\alpha = 0.94$ for supervisors), skill requirement, ($\alpha = 0.84$ for employees, $\alpha = 0.94$ for supervisors), social recognition, ($\alpha = 0.83$ for employees, $\alpha = 0.94$ for supervisors), and growth and flexibility ($\alpha = 0.87$ for employees, $\alpha = 0.93$ for supervisors). This questionnaire has the ability to be effectively used as both a self-reporting tool or as for a supervisor to rate employees.

In other cases, such as in chess, the identification of an expert can be done by a score on an assessment (Chi, 2006). The Elo rating scale (Gobet & Charness, 2006) allows the evaluation of an individual's skill in chess. The Elo scale was created in the 1960s and can be used to rate players in tournaments. Based on his or her score, the individual can be placed in a category showing the individual's level of expertise.

Another way an individual's expertise can be categorized is through observation. For example, consider Berliner's continuum of expertise. Each stage on the continuum contains characteristics of practice. No instrument for Berliner's continuum of expertise was found in the literature. However, observing a teacher may allow an individual to correctly place a teacher on the continuum. This study examined expert performance and discovered characteristics of novices and experts in the domain of lesson planning using technology. These characteristics could be placed in a continuum to give a starting and ending place for technology integration.

How Individuals Become Experts

Some researchers believe that individuals become experts through inherited gifts or talents. Howe et al. (1998) says that "it is widely believed that the likelihood of becoming exceptionally competent in certain fields depends on the presence or absence of inborn attributes variously labeled 'talents' or 'gifts' or less often, 'natural aptitudes'" (Howe et al., 1998, p. 399).

Other than size and weight, other researchers believe individuals do not gain expertise through inherited traits. Bloom (1985) believes that "unless there is a long and intensive process of encouragement, nurturance, education, and training, the individuals will not attain extreme levels of capability in these particular fields" (p. 3). Ericsson, Roring et al. (2007) also raise concerns about expertise being gained through innate talents. They say "we are not aware of any objective evidence showing that only some rare individuals are able to improve their memory because they possess specific genes" (2007, p.4). Instead, they believe individuals become experts through experience and guided practice.

In education, Dunn and Shriner (1999) believe deliberate practice can improve teachers' expertise. They have based their beliefs on the Ericsson (1993) model. In order for teachers to improve their craft, they should work with a mentor or have guidance provided from another individual (Dunn & Shriner, 1999). However, teachers typically receive little to no coaching or guidance after completion of a teacher preparation program.

As teachers spend more time planning for and evaluating their teaching, classroom performance may increase (Dunn & Shriner, 1999). Dunn and Shriner (1999) suggest a possible deliberate practice model in education; planning, preparation, and evaluation. In one of their studies, Dunn and Shriner (1999) found the participant teachers spend about two hours per day completing activities for teaching such as planning, preparing materials, and grading. Most teachers, experts or otherwise, spend about this much time planning and preparing to teach daily. While these daily activities have the "potential to provide a teacher with opportunities to acquire new knowledge of teaching" (p. 644), it is not likely that all planning and preparation activity rises to the level of deliberate practice needed to achieve advanced stages of expertise.

In order for teachers to improve through deliberate practice, they must know how their performance can improve. In other words, the teacher must understand what their performance is currently lacking. The Dunn and Shriner model does not address this. This study identified characteristics of expert performance of TIEs. If teachers can identify characteristics of performance needed to improve, perhaps through the findings of this study, they would know what skills to deliberately practice. This could help lead to increased teacher performance and possibly expertise.

Deliberate Practice

Ericsson, Prietula, et al. (2007) argue the path to expertise revolves around deliberate practice. Deliberate practice is more than just practice. This type of practice focuses on tasks that the individual is not currently competent in completing. Once tasks needing improvement are identified, a systematic, scientific way to improve performance is created, often with the help of a mentor or coach.

An example of deliberate practice used by Ericsson, Prietula, et al. (2007) is often taught in business schools. Students are presented with real-life situations in the business world. These situations are then discussed up to 20 times in class per week. Students are given multiple opportunities to improve their knowledge in a controlled environment.

Another example of how deliberate practice is used is in the United States military (Ericsson, Prietula, et al., 2007). War games are used by military officers for training at military academies. Officers analyze and provide immediate feedback following simulations. This feedback can improve performance for the trainees involved.

Ericsson, Prietula, et al. (2007) have found that expert teachers set a couple of hours a day, typically in the morning, to complete their most difficult tasks. This amount of time would add up to about 700 hours per academic year. If teachers would use this time to practice deliberately, their performance would improve.

How Experts Are Identified

The identification of expertise can occur using a variety of methods. Identification of expertise is unique for each domain. The methods described below are not intended to be an exclusive list of these methods. Instead, these methods only provide a few of the ways expertise can be identified.

Sometimes the identification of expertise is completed through social opinion, such as peer nomination (Ericsson, Roring, et al., 2007). This is especially true in domain where the identification of expertise is difficult (Ericsson, 2006). However, Ericsson et al. (2007) are critical of identifying experts using this system. Identifying experts using this method is quite subjective and popular opinion can frequently change. For example, consider the work of Bach. Shortly following his death, his work was almost entirely forgotten. Today, centuries after his death, he is widely recognized as a genius through examination of his work. Additionally, there is often no measure of the peers doing the nomination. Research has shown that the performance of the peer nominated experts and the individuals doing the nominating were often of no better quality than others in the field (Ericsson, Roring, et al., 2007).

Using social opinion to identify teacher experts may prove to be ineffective. Berliner (1986) states “in the elementary grades a teacher’s reputation, along with classroom observations and consistent excellent classroom performance on standardized tests, may be taken as indicators of expertise despite all the well-known faults inherent in reputational measures, observation, and standardized tests” (p. 8). When a student has multiple teachers per day in the higher grades, the identification of expert teachers becomes even more problematic.

Another method used to identify expertise is the retrospective method (Chi, 2006). In this method, a product is examined to identify expertise at the conclusion of the activity being studied. Domains that may use the retrospective method include music and art. In domains such as music and art, when a product is produced by an individual, expertise may be determined through popularity.

Palmer et al. (2001) studied 29 articles on teacher expertise. In 17 of the 29 selected articles, years of experience was used as a marker to show teacher experience. Most of these articles suggested that teachers would need five to ten years of experience to achieve expertise. The researchers found that 18 of the 29 studies used social recognition or nomination to identify expertise in teachers. Another indicator of expertise identified in 13 of the 29 articles was professional or social group membership. Finally, a performance criterion was used in 17 of the 29 studies. After their research, the authors of this article suggest considering both experience and social nomination and recognition for finding expert teachers. Teachers should have had at least five years of experience. Additionally, since expertise is highly contextualized, teachers should have at least three years of experience in the same context. Teachers should be nominated through a rigorous process that contains at least two different nominating parties. The nominations could be as a result of evidence based on student performance or as a result of process indicators of quality teaching.

A rating system is another method that can be used to identify expertise (Chi, 2006). By using a rating system, an individual is given a score based on performance. In this case, an individual can easily be compared to another to determine proficiency. An example of using a rating system for expertise identification is in chess. Expertise can easily be determined through the rating scale score.

Yet another method to identify expertise is using an independent index (Chi, 2006). In this method, an individual can be given a task to measure performance, such as the Knight's Tour in chess. In this test, an individual is tasked with moving a Knight Piece across the back row of the chess board using only legal moves. An individual's chess skill can be measured by the time needed to complete this move. Tasks such as this study "the remarkable few to understand how they are distinguished from the masses" (Chi, 2006, p. 22). No index such as this can be found in the literature to help determine the expertise of teachers, however, this study identifies the characteristics of novice and expert performance. These characteristics could be used to help create a partial index.

Chi (2006) believes placing expertise on a continuum can aid in studying expertise because this method allows less precision to be effective. By studying expertise using this relative approach, one can relate the expertise of an individual to a novice. In this approach, a goal is to understand how we can enable a less skilled or experienced persons to become more skilled since the assumption is that expertise can be attained be the majority of students" (p. 23). Studying expertise in this manner allows the path to expertise to be identified so it can be replicated for other individuals to follow. In other words, it can provide a blueprint to acquiring expertise in a domain.

Chi (2006) has adapted a six stage proficiency scale. This scale can serve as a general continuum for expertise regardless of the domain. An explanation of this proficiency scale is provided below.

Novice. An individual who is a novice is completely new to the domain. At best, this individual has had minimal exposure to the domain.

Initiate. An initiate is an individual that has had minimal, if any exposure to a domain. Unlike a novice, the initiate has just begun introductory instruction.

Apprentice. An apprentice is an individual who is learning in a domain. The apprentice receives instruction or guidance from an individual more competent. One can remain in the apprentice stage anywhere from one to twelve years.

Journeyman. A journeyman can complete a day's work unsupervised but is working under orders. This individual is an experienced and reliable worker who has achieved a high level of competence. It is possible for an individual to never move pass this stage, even with a high degree of motivation.

Expert. The expert is a capable journeyman that is highly regarded by his or her peers. This individual can deal with difficult or unusual cases a typical journeyman cannot. An expert has special skills or knowledge from subdomains a journeyman may not have.

Master. A master is a journeyman or an expert that is also qualified to teach at lower domains. Traditionally, a master is the individual or part of a group who sets regulations, standards, and ideals.

Empirical Ways of Finding Expertise

In some domains, such as chess, identifying expertise has become much easier than in other domains. A well-defined rating scale in chess, called the Elo rating scale, easily identifies the stage of a chess player based on his or her score (Gobet & Charness, 2006). The scale has been in existence since the 1960s. One could have a score as low as zero or as high as 2,800, as the world's best players do. Grandmaster status is reached with a score of about 2,500, International Master with a score of about 2,400, and Master is achieved with a score of about 2,200.

Most people in education may argue than finding an expert teacher is difficult. Berliner (2001) explains that the identification of expertise has historically been hampered for two reasons. First, it is much more difficult to identify an expert teacher than other domains, such as chess, because there is no objective measure. Secondly, it has been difficult to show the effects a teacher has had on his or her students. However, with the creation of National Board Certified Teachers in 1994, the process may have become much easier, and perhaps, even more objective (Ericsson, 2007).

National Board Certified teachers were compared to other teachers in thirteen different features in a study conducted by Bond (2000, as cited by Berliner, 2004). Bond, Smith, Baker, and Hattie (2000) chose the thirteen features after conducting a literature review on expertise of teaching. The literature review revolved around the work of Berliner and Shulman. The following is a list of these features (Berliner, 2004, p. 209):

1. better use of knowledge;
2. extensive pedagogical content knowledge, including deep representations of subject matter knowledge;
3. better problem-solving strategies;
4. better adaptation and modifications of goals for diverse learners and better skills for improvisation;
5. better decision making;
6. more challenging objectives;
7. better classroom climate;
8. better perception of classroom events and better ability to read the cues from students;
9. greater sensitivity to context;
10. better monitoring of learning and providing feedback to students;
11. more frequent testing of hypotheses;
12. greater respect for students; and
13. display of more passion for teaching.

For this study, teachers who attempted to become National Board Certified were divided into two separate groups; a group that achieved National Board Certification

(N=31) and a group that did not achieve National Board Certification (N=34). According to Berliner (2004), “all the teachers were well experienced, had prepared diligently for the examinations, and spent considerable amounts of money to demonstrate that they were highly accomplished teachers (p. 209).” Berliner (2004) makes sure to point out that this study was not between expert teachers and nonexpert teachers. Instead, it was a comparison of highly accomplished teachers.

The results of the research indicate that in all thirteen comparisons, teachers who passed the National Board Certification obtained a higher mean score (Bond et al., 2000). In eleven of the thirteen features, the national board certified teachers (NBCT) scored significantly higher than the other teachers. Only the features of monitor learning and provide feedback and multidimensional perception were not statistically significant. Additionally, NBCT were able to increase student achievement much higher than teachers who were not NBCT. In fact, during this study, there was no case in which the gains of students of non-NBCT were significant (Berliner, 2004). It appears that the identification of teachers through this method has proven effective in this study.

In order for a teacher to become National Board Certified, a teacher must possess a bachelor’s degree from an accredited institution, be state certified, and have three years teaching experience (Harris & Sass, 2007). If teachers meet these requirements, three main components are needed to be completed for Board Certification: initial screening, preparation of a portfolio and successful completion of a set of assessment exercises” (Harris & Sass, 2007, p. 1).

Others, however, are skeptical of the claims that students of NBCT outperform the students of other teachers. These skeptics often site a lack of research as reason to doubt these claims (Goldhaber, 2004). Additionally, “teachers with stronger credentials tend to teach in schools with more advantaged and higher performing students…” (Clotfelter, Ladd, & Vigdor, 2007, p. 5). Seemingly, only North Carolina’s state test allows the matching of student test scores to specific teachers, thus making the effects of a teacher’s expertise difficult to quantify (although recent efforts by a growing number of states to tie test scores to teachers’ evaluations may soon change this).

Another possible way of identifying experts is by asking an individual to complete an authentic task (Bransford & Schwartz, 2009). For example, in golf, attempting to make a long putt would be an authentic task. If this task can be completed at a higher percentage than most people, a possible test for expertise would be passed. In education, this may be accomplished if teachers have a clear knowledge of performance conditions. Teachers must be familiar with the age of the students, the subjects, and the student population. “Teachers who have this knowledge can create conditions that allow them to continually assess students’ progress toward authentic tasks” (Bransford & Scwartz, 2009, p. 761).

Importance of Expertise in Education

Empirical evidence exists showing teachers identified as experts in pedagogy positively affect student achievement (Berliner, 2004). In a study of 600,000 elementary students in North Carolina, students of NBCT raised their achievement in math and reading by about 7% more than students of teachers who were not NBCT. Another study shows that students of 35 NBCT taking the Stanford Achievement Test, 9th Edition achieved higher scores than students of non-NBCT.

A recent study from researchers at Columbia University and Harvard show how the very best teachers can have long-lasting impacts on their students (Chetty, Friedman, et al., 2011a). This study examined the effects of value-added (VA) teachers. The researchers defined value added "as the average test-score gain for his or her students, adjusted for differences across classrooms in student characteristics such as prior scores" (Chetty, Friedman, & Rockoff, 2011b, p. 1). This study examined the bottom and top 5% of the teachers as measured by the district's year end test. Approximately 2.5 million students in grades 3-8 were studied from the years between 1989-2009. These scores were compared to tax records from 1996-2010 that contained information on earnings, college attendance, teenage births, and parent characteristics. Approximately 90% of the data was matched between the two sources.

This study showed the effects of a teacher, even for one year, are quite substantial. A student who is taught by a bottom 5% teacher as opposed to being taught by an average teacher for just one year would make $52,000 less on average in lifetime earnings. The effects of this teacher on an average classroom would mean approximately $1.4 million in potential lost earnings for the total class.

Having a teacher in the top 5% would mean the exact opposite. In fact, researchers have shown a top 5% teacher in a new teaching position would improve scores for the entire grade level (Chetty, Friedman, & Rockoff, 2011a). A student who has a top 5% teacher for one year from grades 3-8 will earn approximately $25,000 more in lifetime earnings than an average teacher. These students "are more likely to attend college, attend higher-ranked colleges, earn higher salaries, live in higher SES neighborhoods, and save more money for retirement (Chetty, Friedman, & Rockoff, 2011a, p. 1). Additionally, these students are less likely to have children as a teenager.

Types of Expertise

Hatano and Inagaki (1986) have theorized two distinct courses of expertise; routine expertise and adaptive expertise. Depending on the task, one of these types of expertise may be more appropriate to complete a task.

Routine Expertise. In routine expertise, an individual has the ability to perform a specific skill at a high level under controlled conditions. These individuals “merely learn to perform a skill faster and more accurately, without constructing/enriching their conceptual knowledge, even after some room in their attentional resources has been produced through automatization of the procedure” (Hatano and Inagaki, 1986, p. 31). Individuals who possess routine expertise “are outstanding in terms of speed, accuracy, and automaticity of performance, but lack flexibility and adaptability to new problems” (Hatano and Inagaki, 1986, p. 31). Due to their speed and level of performance, most may argue these individuals are in fact experts. However, these experts are not able to use their knowledge in a different environment than they are accustoming to performing.

Adaptive Expertise. Sometimes, an individual can take his or her routine knowledge, which consists of primarily procedural skills, and invent other procedural knowledge. In essence, an individual is altering his or her routine knowledge to help create improved performance. Hatano and Inagaki (1986) call this phenomenon adaptive expertise.

When routine expertise occurs in a controlled environment with few or no variables, little need exists to change the expert performance. However, in instances where a procedure occurs with variations, adaptive expertise may be more likely to occur, probably out of necessity. Since teachers aren't always able to completely control the classroom environment, adaptive expertise may be frequently used.

Metacognition

Schraw and Dennison (1994) consider metacognition "the ability to reflect upon, understand, and control one's learning" (p. 460). Lin, Schwartz, and Hatano (2005) define metacognition as "the awareness and regulation of the process of one's thinking" (p. 246). Some researchers believe metacognition and expertise may be related. In fact, metacognition may actually aid an individual practice which can lead to expertise. Sternberg (1998) states that "metacognition is viewed as part of the concept of developing expertise" (p. 132). He believes that the literature on metacognition and expertise "may be talking, at some level, about the same thing" (Sternberg, 1998, p. 132). Although researchers have not yet devised a clear definition of metacognition (Kitchener, 1983), they have been able to agree on specific components of it. Many researchers agree that metacognition has three distinct parts (Kitchener, 1983). Kitchener (1983) describes these parts as:

> (a) knowledge about self and others as cognitive processors when they are engaged in a task or goal,
>
> (b) knowledge about specific cognitive tasks or problems themselves and
>
> (c) metacognitive experiences, i.e., feelings or wonder or puzzlement which lead to the reevaluation of strategies. (p. 222-223)

Adaptive Metacognition

Due to the complexities of the classroom, teachers need many strategies to use in a variety of situations and with different students. Using “adaptive metacognition involves both the adaptation of one’s self and one’s environment in response to a wide range of classroom variability” (Lin et al., p. 245). “Teachers often need to reflect on their values and the consistency between their own values and those of the other members in the community (parents, students, principals) to guide them towards an acceptable solution” (Lin et al., p, 248). If teachers are successfully able to adapt their teaching to each specific and unique situation, greater student success could result.

Metacognition and Technology

On occasion, a new technology artifact may force a teacher who practices metacognition to change his or her teaching (Lin, 2001). In this case, the artifact was “a video-based story involving mathematics problem solving from the Jasper Woodbury series (referred to as Jasper) developed from Vanderbilt University” (Lin. 2001). This artifact allowed both the teacher and students to reflect on their performance, eventually leading to change classroom practice. Lin has coined this term reflective adaptation or adaptive metacognition. While using adaptive metacognition in conjunction with the results of this study, teacher performance could be improved without the assistance of a mentor or coach.

When considering the implementation of a new technology artifact in the classroom, Lin (2001) suggests careful consideration of three aspects: “(a) the affordances of the artifact, (b) support and constraints offered by the local culture, and (c) the kinds of reflection and decisions that influence the adaptation” (p. 431).

In the first of these aspects, artifacts can help to turn abstract ideas into real experiences. In this case, the use of technology allowed designers to show a certain aspects of the practice in a detailed manner (Lin, 2001). This detail provided through the use of technology would be either difficult or impossible to chronicle without its use. In essence, technology can be a catalyst for change.

A new technology artifact in the classroom can be influenced by the local culture (Lin, 2001). In order for a new technology artifact to be used successfully, the local culture may need to be ready to accept the innovation. Without support for the culture, the introduction of a new artifact may not be embraced.

Finally, when introducing a new artifact, teachers able to successfully integrate a new artifact are essential (Lin, 2001). This introduction can be more difficult in a situation where teachers do not have the support or resources needed for successful integration. Teachers may have to change prior practices or routines for successful integration.

Creating Expertise in Education

As with other domains, the most important factor in creating expertise in education is experience (Berliner, 2004). The second most important factor is good coaching. Effective coaching of novice teachers may shorten the amount of time needed to achieve expertise. The third most important factor in creating expertise in education is practice. The idea of practicing lessons is widely used in Japan. This allows teachers to receive feedback from peers and gives an individual an opportunity to improve his or her lesson before using it in the classroom. Berliner (2004) believes that “experts in teaching share characteristics of experts in more prestigious fields such as chess, medical diagnosis, and physics problem solving" (p. 210). Thus, Berliner believes the path of gaining expertise in education should be very similar to the path of gaining expertise in other fields. However, other researchers (Ericsson, 2007) believes expertise is acquired through guided practice.

Hattie has identified five dimensions of expert teachers. Expert teachers can: (a) identify essential representations of their subject, (b) guide learning through classroom interactions, (c) monitor learning and provide feedback, (d) attend to affective attributes, and (e) influence student outcomes" (p. 5, 2003). From these five dimensions, 16 prototypic attributes of expertise in education were created. The following paragraphs contain Hattie's 16 attributes.

A1. Expert teachers have deeper representation about teaching and learning. Experts in teaching may not possess more knowledge than other teachers; however the way these teachers organize and use their knowledge may be different. Their knowledge is more integrated than the knowledge of other teachers. Expert teachers are able to relate lessons to prior knowledge and to other subjects. This knowledge allows expert teachers to change what is occurring in the classroom spontaneously, allows them to make better prediction of classroom outcomes, and allows them to be more responsive to their students. According to Hattie, "expert teachers are VERY context bound, and find it hard to think outside the specifics of their classrooms and students. Generalization is not always their strength" (p. 6, 2003).

A2. Expert teachers adopt a problem-solving stance to their work. Often, experienced teachers focus solely on data for the entire class. According to Hattie (2003), expert teachers seek more information about each individual student. The expert teacher is able to be more flexible in their teaching, taking advantage of the new information.

A3. Expert teachers can anticipate, plan and improvise as required by the situation. As compared to experienced teachers, expert teachers are better able to anticipate problems and then improvise to solve them. Often, experts try to spend more time trying to understand the problem than to introduce more solutions (Hattie, 2003).

A4. Expert teachers are better decision-makers and can identify what decisions are important and which are less important decisions. Through improvisation, expert teachers are better decision makers. In fact, a study shows that none of the participating expert teachers had written lesson plans. However, all of these teachers could easily describe their mental lesson plans. Most of these mental lesson plans contained a sequence of lesson components and content, but did not contain how many problems or the amount of time needed. Instead, pacing and the number of practice problems were dictated by the performance of the students. Students' questions and comments were used for discussion (Hattie, 2003).

B5. Expert teachers are proficient at creating an optimal classroom climate for learning. A positive classrooms classroom climate can be characterized as a classroom where students feel free to make mistakes, where questioning is high, where students are typically engaged, and where students have a reputation as effective learners (Hattie, 2003).

B6. Expert teachers have a multidimensionally complex perception of classroom situations. Expert teachers are more effective at scanning for classroom behavior, and make greater references to the learning and language of the students. Other teachers are more concerned with what the teacher is doing or saying, not on what the students are doing.

B7. Expert teachers are more context-dependent and have high situation cognition. In order for an expert teacher to maximize his or her ability, the expert teachers must be practicing in his or her normal setting. Expert teachers are often concerned with the ability, experience, and background of the students being taught. In other words, the expert teacher is most effective teaching in context.

C8. Expert teachers are more adept at monitoring student problems and assessing their level of understanding and progress, and they provide much more relevant, useful feedback. Through more and better feedback, expert teachers are able to determine when students lose interest or when students do not understand information. Because of this process, expert teachers are better able to anticipate and prevent disturbances. Non-experts, instead, must correct these disturbances after they begin.

C9. Expert teachers are more adept at developing and testing hypotheses about learning difficulties or instructional strategies. Through gained feedback, experts develop and test hypotheses to try determine the effectiveness of his or her teaching.

C10. Expert teachers are more automatic. Expert teachers perform better than non-expert teachers and do so with less effort. Their cognitive skills, through extensive practice, become automatic. This allows expert teachers to free up working memory to deal with more complex parts of the situation. Hattie (2003) warns that this is not enough to distinguish expert teachers from non-expert teachers.

D11. Expert teachers have high respect for students. Sometimes, experienced teachers tend to create physical and psychological distance between them and their students. Expert teachers tend to be more receptive to what the students want and do not dominate situations. Additionally, expert teachers tend to demonstrate a higher commitment to their students.

D12. Expert teachers are passionate about teaching and learning. Expert teachers show more emotion about the successes and failures in their work. This may be due to a sense of responsibility felt by expert teachers.

E13. Expert teachers engage students in learning and develop in their students' self-regulation, involvement in mastery learning, enhanced self-efficacy, and self-esteem as learners. Expert teachers try to motivate their students to master concepts. They also enhance students' self-concept and self-efficacy about learning. Expert teachers assign tasks for surface learning and for deep outcomes.

E14. Expert teachers provide challenging tasks and goals for students. In a typical classroom, 80% of the time is spent with teachers talking and student listening (Hattie, 2003). Expert teachers have students engaged in tasks more of the time. Expert teachers set challenging goals for their students instead of having students complete time consuming activities.

E15. Expert teachers have positive influences on students' achievement. Although no dependable and credible way exists to measure teacher effect on student achievement, the gold standard of expertise in education is student achievement.

E16. Expert teachers enhance surface and deep learning. Surface learning is about learning content. Deep learning is about developing an understating. Both experienced and expert teachers are able to develop surface learning in their students. Expert teachers are better able to develop a deep understanding with their students.

Guided Practice

Ericsson et al. (2007) has suggested expertise can be acquired through guided practice. Two studies completed by Dunn and Shriner (1998) show the effects of guided practice in education.

In the first study, 136 teachers, through a questionnaire, indicated that informal and formal evaluation and planning activities “best parallel deliberate practice activities that Ericsson and colleagues report as accounting for expertise in other domains” (Dunn & Shriner, 1998, p. 631). In other words, in order to improve their performance as a teacher, teachers must deliberately improve the practice of lesson writing. In the other study conducted by the same researchers, eight teachers, through log data and interviews, indicated that these activities can lead to expertise in education, although these activities may not be enjoyable. However, since there is not a consistent definition available in the literature for a TIE, a definition or list of characteristics leading to expertise in this domain must be created. This study identified these differences.

Identifying Expertise

Factors consistent with expert teaching are listed below (Pierson, 2001). These factors are comparable to expertise in general, not just education.

1. Use knowledge during planning, combined with experience, to set goals for student learning
2. Make a greater number of contingence decisions
3. Consider management and instructional strategies prior to teaching

4. Rely on a set of routines to automatize recurring teaching
5. Use experience to predict student learning needs
6. Use student input to tailor lessons
7. Can monitor multiple classroom events simultaneously
8. Has the ability to analyze situations at deeper levels and can propose solutions.

Ericsson, Prietuka, et al. (2007) believe that expert teachers plan differently than other teachers. “In fact, most expert teachers and scientists set aside a couple of hours a day, typically in the morning, for their most demanding mental activities, such as writing about new ideas” (Ericsson, Prietula et al., 2007, p.119). Although this seems like an inconsequential amount of time, over the course of a year it could add up to about 700 hours. This additional time designed to improve performance, or as Ericsson would call it, deliberate practice, may allow an individual to improve his or her performance.

This study closely examined the planning of both novices and TIEs and compared the two of them together. These differences resulting in this comparison show how TIEs plan differently than novices. If these differences can be deliberately practiced by novices, their performance will improve.

Continua of Expertise in Education

Meskill et al. (2002) conducted a small study that created a four-stage continuum of expertise in using technology in education. Their study compared the differences between eight total teachers ranging from preservice teachers using technology to experts. Teachers were placed in a continuum based on their performance. The identification of expertise for this study was not stringent and was only based on number of years taught (eight to ten).

In their research, Meskill et al. (2002) theorized teachers using technology effectively did so because they used technology as a means for learning, they used it in an advisory role, and because it created a need for teachers to expand their repertoires.

The first stage in the Meskill et al. (2002) continuum is the *locus* stage. In this stage, the emphasis is on the technology and not on student learning. When teachers in this phase experience technical issues, teachers have difficult in creating a contingency plan. Instead, these teachers attempt to fix the problem, and may become easily frustrated due to lack of technical knowledge.

In the second stage, or the *focus* stage, teachers no longer placed the emphasis on the technology being used. Instead, emphasis was placed on the learning of the students. However, teachers still made educational decisions for students. Teachers in this phase still completed tasks such as setting up software and printing out papers for students. At times, teachers in this phase feel technology can burden them.

The third phase of the Meskill et al. (2002) continuum is the *practice* phase. Instead of using computers for rewards or punishment, teachers in the practice phase use technology to complement and enhance the learning experience for students. Teachers in this phase recognize the power of technology to provide additional learning opportunities for their students.

In the final phase, or the *emphasis* phase, an emphasis is placed on not just the products students are creating, but also the process of learning. Teachers in this phase are able to find teachable moments during the use of technology, and not just when the end product is examined.

Even though the term expertise is not used, Pierson (2001) believes that two models exist that show the process of teacher technology adoption through five stages. As a teacher achieves the highest stages of technology integration, technology helps the teacher to redefine his or her teaching.

A model that Pierson (2001) mentions dates back to the Apple Classrooms of Tomorrow (ACOT) research (Ringstaff, Sandholtz, & Dwyer, 1991). The researchers created a five stage model of technology integration; entry, adoption, adaptation, appropriation, and invention. In the initial phase of this model, Ringstaff et al. (1991) find that "teachers demonstrated little penchant for significant instructional change and in fact, were using their technological resources to replicate traditional instructional learning activities" (p. 5). Eventually, as teachers reached the appropriation phase, whole-group lectures and individualized seatwork began to diminish and students began to learn in new ways.

Another model Pierson (2001) mentions is a model created by Hooper and Rieber (1995). The stages in this model include familiarization, utilization, integration, reorientation, and evolution. Not until the integration stage does a teacher truly rely on a piece of technology. If the technology becomes unavailable, the teacher is no longer able to complete a lesson. Eventually, in the evolution phase, the classroom is constantly changed to meet the needs of diverse learners through technology.

Acquiring Expertise in Technology Integration

In 1998, a small qualitative study was conducted studying elementary teachers who were identified as exemplary technology users (Pierson, 2001). Nominations were made by the district director of technology, two teachers on assignment for technology, school media specialists, and principals. In all, 24 teachers agreed to participate in the study and 16 were actually observed for screening. The 16 teachers were observed for a half of day each. Finally, one teacher was chosen to study in each of the three different experience levels; exemplary technology use, adequate teaching, and exemplary teaching. Pierson (2001) identified several factors which help lead to expert performance in technology integration. Teachers well versed in teaching with technology spend substantial time working with technology, have had more extensive computer training, have more experience, and have high levels of confidence and innovativeness. Additionally, these teachers are surrounded by colleagues who used technology for meaningful activities and also receive school and district level support including sufficient staff development opportunities.

Identifying Experts in Technology Integration

According to TPACK (Mirsha & Koehler, 2006), in order for a teacher to be an expert in technology integration, the teacher must be an expert in three separate domains; technology, pedagogy, and content knowledge. In other words, according to this theory, to find an expert in technology integration one must find a teacher who is an expert in all three of these fields. Since expertise is typically limited to a specific domain (Chi, 2006), finding a teacher who is not just competent, but an expert in all three domains may be challenging. However, Ericsson, Prietula et al. (2007) may provide a way of identifying technology integration experts. They believe that expert teachers plan differently than other teachers.

If TIE teachers do in fact plan differently that other teachers as Ericsson, Prietula, and Cokely (2007) suggest, a careful examination of the thoughts and judgments of TIEs would lead to characteristics of export performance that could be replicated. A possible manner to examine this performance is through cognitive task analysis. Participants in this study were examined trough this lens.

Cognitive Task Analysis

Cognitive Task Analysis (CTA) is a way to study cognition in real world settings (Crandall, Klein, & Hoffman, 2006). It allows researchers a blueprint to study expert performance in hopes to learn how and why experts performed at such a high level. Ultimately, in the present context, it may lead to a method to improve staff development which in turn could lead to more technology integration experts.

The use of CTA began in the early 1980s as a response to corporate and military leaders requesting a new method that would lead to a better design for training individuals in the workplace (Militello & Hoffman, 2008). The hopes of these leaders were to reduce the likelihood of errors in the workplace and to learn how to better use new technologies. According to Militello and Hoffman (2008) CTA has roots in the following threads of modern research; cognitive systems engineering, sociological and ethnographic literatures, cognitive work analysis, naturalistic decision making, and human-centered computing. Some of these roots can be traced back to the late 1850s.

Crandall et al. (2006) believes CTA falls in the “middle of the analytic spectrum, drawing on both quantitative and qualitative analysis techniques (p. 108). While being neither quantitative or qualitative, CTA has the power to use powerful techniques from both. Since CTA is often exploratory in nature, the use of qualitative techniques during data collection can be beneficial. CTA does however radically differ from qualitative research due to a focus on cognitive decisions, something that is not a focus in qualitative research. Additionally, CTA uses quantitative techniques, especially in data analysis, in a manner not frequently used in qualitative research. The researcher in CTA has a wealth of data collection and data analysis tools at his or her disposal. He or she must carefully choose the correct tools for their research.

CTA consists of three separate components; knowledge elicitation, data analysis, and knowledge representation. Several techniques are available for researchers to use in each of the three components.

“Knowledge elicitation is the set of methods used to obtain information about what people know and how they know it: the judgments, strategies, knowledge and skills that underlie performance” (Crandall et al., 2006, p. 10). CTA knowledge elicitation can be classified into the way the data is collected. Some of the CTA methods that can be used in the knowledge elicitation phase are interviews, self-reports, observations, and automated captures.

The second component of CTA, the data analysis phases consists of three different phases; preparation, data structuring, and discovering meaning. In the first phase, researchers are primarily concerned with ensuring the data is completely and accurately recorded in a useful format. In order to save time later, the researcher must go back and fill in any vacant holes. Next, the data is structured in an organized manner in an attempt to identify patterns. This will make the identification of themes easier later in

the process. In the final phase, or discovering meaning, the data is looked at in a more general context. “The central task in this phase of analysis is to locate the significant findings and insights contained in the data” (Crandall et al., 2006, p. 117).
Finally, the findings from data analysis must be represented and communicated. Data may be formed into narrative formats, chronologies, data organizers, process diagrams, or concept maps.

Often, such as in a concept map, a knowledge elicitation method also contains a way to both analyze and represent the data. “Concept maps are diagrams used to represent and convey knowledge” (Crandall et al., 2006, p. 43). A quality concept map can be used to retain knowledge more effectively, apply knowledge in novel settings easier, and can be used in evaluation.

Cognitive Task Analysis allows a great deal of flexibility during research. In a domain where little or no theory exists, CTA provides researchers a systematic approach to collecting and analyzing data of cognitive tasks made by individuals; a task that can often be overwhelming. With this in mind, techniques from CTA were used in this study.

In the current workplace, advances in machine responsibility and technology have increased the cognitive demands on people while diminishing procedural tasks (Militello & Hutton, 1998). These demands have made many of the high level jobs even more complex. CTA allows researchers an opportunity to study the hands-on skills and experiences of these expert individuals in order to find what type of experiences make an individual into an expert.

The Knowledge Audit (or Applied Cognitive Task Analysis)

"The most thoroughly tested and validated adaptation of the critical decisions method (CDM) concept is the Knowledge Audit Method" (Crandall et al., 2006, p. 88). The knowledge audit covers eight different dimensions of expertise; past and future, big picture, noticing, job smarts, improvising/spotting opportunities, self-monitoring, anomalies, and equipment difficulties (Crandall et al., 2006, Militello & Hutton, 1998). This method can serve as a streamlined interview technique and is well suited for researchers who are new in using CTA. The Knowledge Audit Method (Crandall et al., 2006) is also known as Applied Cognitive Task Analysis or ACTA (Mitello & Hutton, 1998).

Techniques used for ACTA were developed in a two-year project funded by the Navy Personnel Research and Development Center (Mitello & Hutton, 1998). The goal of this project was to gain critical cognitive elements from experts. Three stages exists in the ACTA interview; the task diagram interview, the knowledge audit, and finally the simulation interview. These are the steps and methods used in the present study.

In the first stage, the task diagram, the expert is asked to break a task into three to six steps or tasks. These tasks will be further broken down into a diagram. This diagram will serve as a road map for the event being researched (Militello et al., 1997). Although the diagram is only meant to describe the task into a surface-level look, it does give the researcher a tool to go into depth about each of the steps with the expert at a later time. The idea for this technique is to examine the big picture and to not go into too much depth. The task diagram provides a focus for the rest of the process.

Militello et al. (1997) also considered other approaches to create a diagram such as concept mapping and team schematics. The researchers found that these techniques were not nearly as practical as the task diagram. These other techniques proved difficult for researchers to use and the product was frequently difficult to understand for others not associated with the interview.

The second stage, the knowledge audit, is primarily concerned with identifying ways in which expertise is used in the domain and to provide specific examples based on experience from the expert. In other words, it is primarily concerned with capturing the most important aspects of expertise in a domain. During the task diagram, the task requiring the most expertise is identified by the expert. This task becomes the focal point of the knowledge audit. Mitello and Hutton (1998) have identified knowledge categories to characterize expertise during the knowledge audit; diagnosing and predicting, situation awareness, perceptual skills, developing and knowing when to apply tricks of the trade, improvising, metacognition, recognizing anomalies, and compensating for equipment limitations. Probes have been created in order to help a researcher gain the sought after knowledge. The probes are designed to help a researcher find if each component is present in the task, the nature of these skills, to identify specific events requiring these skills, and strategies that have been successfully used. Finally, the expert is asked for errors a less experienced person may have made. This provides a comparison of the differences between a novice and an expert in specific situations.

Finally, the simulation interview is given to the expert. This is a challenging situation given to the expert in order to obtain foundational information. Due to the nature of education, it is difficult to get information from a participant in context. The simulation interview is a way for a researcher to get at cognitive demands of an expert in a specific, pre-determined scenario. It is designed to understand the decisions and judgments experts make (Militello et al., 1997). The simulation may be done by a paper and pencil exercise, a creation of a map or diagram, or even a computer simulation. Often, these situations provide more than one acceptable answer. Obtaining information from multiple experts could ultimately help in the creation of training.

In order to present data in a consolidated manner, Militello et al. have created the cognitive demands table. “These tables were intended to represent the critical decisions and judgments in a task and how these decisions and judgments are made” (Militello et al., 1997, p. 13). This table allows the researcher a manner in which to place information from multiple interviews into a single representation. This representation has the ability to serve as a reference for training interventions or cognitive skills training.

Mitello and Hutton (1998) created a study of ACTA techniques, the same ones used in this study, in order to determine the validity, reliability, and usability of their techniques. The researchers created parallel studies of two separate domains, firefighting and naval Electronic Warfare (EW). The study was carried out using the aforementioned ACTA techniques by novice researchers who lacked knowledge or experience with CTA or instructional design. The researchers for this study were volunteer graduate students who were paid $250. A total of 23 students participated in this study; 12 researching firefighters and 11 researching EW. In each of the domains, students were purposefully placed into two groups based on age, gender, and educational level. These groups were randomly assigned to study experts from either domain. All of the students attended a two hour workshop which introduced the participants to CTA. At the conclusion of the training, students joined their respective groups for the remainder of the study; one group was asked to interview experts in any format of their choosing and the other group used ACTA techniques. The group using ACTA techniques was given an additional six hours of training on ACTA techniques.

Regardless of group placement, each student participated in two interviews with experts. In one interview each student interviewed the expert. In the other interview, the student observed the expert interview. Each student attended a four-hour session in order to analyze the data and to develop training materials. Students were given a specific format in order to present the data.

Participants from both domains indicated the interviews were informative and the results from the interviews allowed them to provide cognitive information about the job (Mitello & Hutton, 1998). The participants also indicated the developing a cognitive task demands table was easy to use. The authors of this study were surprised by the few differences in the tables of the two groups. The means between the two groups were not very different however there was a large standard deviation between the two groups. The authors concluded the group receiving training was more confident during the process.

Cognitive Task Analysis in Education

In the field of education, recent research shows CTA can be effective when properly used to plan instruction. In a study published in 2010, researchers found using lessons designed by interviewing expert professors through a CTA framework in a college biology course yielded fewer withdrawals and student performance was improved (Feldon, Timmerman, Stowe, & Showman, 2010). Three expert biology faculty members were recruited to participate in this study. Each of the experts had been engaged in biology research for at least ten years, had articles published in top journals, and had been acknowledged by peers as being highly skilled in the scientific process. The experts were interviewed for about two hours each with careful attention given to how the expert approached the scientific process. During the interviews, decision points were identified and events were cued that led to a specific strategy relevant to the problem solving process. At the conclusion of each interview, transcripts were analyzed to develop a representation of the process as characterized by the expert. The experts then reviewed the representations for any necessary additions or revisions. Finally, the three representations were synthesized into a single representation that was reviewed by all three experts.

After creation of the final representation from the experts, a series of video-based lessons were created, based on the final representation, and given by a tenured, award-winning professor.

According to this study, undergraduate majors in the biological sciences have a dropout rate of 50%. One of the greatest factors for this dropout rate is poor instruction. The authors of this study believe that using CTA to plan instruction leads to the following two benefits (Feldon et al., 2010, p.10):

The first is that the instructions provided to the students are more complete (fewer steps, criteria or decision points are likely to be omitted). Second is that the explicit nature of the instructions generated by CTA provided a level of precision and detail that is otherwise unavailable for student. These instructions contain lower levels of extraneous cognitive load and fewer knowledge gaps. The decrease in cognitive load potentially leads to fewer instances of burnout, because sustained task demands are less likely to exceed working memory capacity of students receiving CTA-based instruction.

In this study, using CTA allows the researcher to identify the cognitive demands identified by both novices and TIEs when planning technology-rich lessons. These demands were probed and the physical tasks resulting from these decisions were identified. The resulting differences of planning technology-rich lessons between novices and TIEs were identified. The identification of these differences can be used as a way to increase the performance of non-experts in this domain.

Summary of the Literature Review

A review of the literature shows two basic theories on how an individual can acquire expertise; innate talents and a product of experience. Many researchers have discounted the theory of innate talents when discussing expertise. Instead, these researchers believe expertise is acquired through guided practice and typically takes about a decade to achieve.

Expertise occurs in stages. Many researchers have created a variety of stages in different domains. An individual can be placed into one of these stages by a careful examination of his or her performance. Once an individual is placed in a stage, skills needed to be proficient in the next stage can be identified. Creating a plan for deliberate practice can improve the individual’s performance.

In education, research has shown expert teachers plan differently than other teachers. These expert teachers typically spend up to two hours a day on their most difficult tasks; often planning and evaluating their teaching. Teacher performance, and ultimately student achievement, could be increased by replicating this model of deliberate practice. Improving teacher performance and student achievement are the underlying goals of this study.

Cognitive Task Analysis (CTA) provides a researcher a wide variety of research tools to examine expert performance. Due to the variety of tools available to researchers, CTA has the flexibility to work in nearly any domain. Using CTA allows researchers to examine expert performance, identify characteristics of expert performance, and to help create a blueprint to replicate expert performance.

For this study, a streamlined version of CTA, applied cognitive task analysis (ACTA), was chosen (Mitello & Hutton, 1998). ACTA was designed as a way for novices to conduct applied research, specifically to examine expert performance. Additionally, after an extensive review of the literature, no examples of the ACTA methodology were located in the field of education. The introduction of a structured methodology designed to study expertise in education could aid researchers in this field. For the aforementioned reasons, ACTA was chosen as the methodology for this study.

Importance of Studying Expertise

Teacher education programs and professional development in schools do not always adequately prepare teachers to be TIEs (Harwell, 2003, Yoon et al., 2007). Currently, a gap of empirical knowledge in regard to the requisite knowledge needed to be a TIE exists in the literature. Identifying experts and comparing their performance to novices in this study led to new insights on what separates these experts from other teachers. Through a careful examination of these TIEs, compared to novice teachers who use technology, this research identified characteristics present in the lessons of TIEs that was not present with the lessons of novice teachers. Teacher preparation programs and professional development can consider these characteristics in their curriculum. If the actions of these TIEs can be replicated, students could receive improved instruction from better trained teachers. Ultimately, this research may lead to increased student achievement.

CHAPTER III

METHODOLOGY

Research Questions

In this study, the identification and study of technology integration experts (TIEs) compared to novice teachers led to attributes associated with expertise in this field. The following questions were created to help the researcher distinguish TIEs from other individuals in the field.

1. What is the decision-making process TIEs use when planning to teach technology-rich lessons?
2. What is the decision-making process novice teachers use when planning to teach technology-rich lessons?
3. How do TIEs plan to teach with technology differently than novices?
4. When planning to use technology-rich lessons, what mistakes do novice teachers make that TIEs do not?

Participants

A total of eight upper elementary teachers were selected from a pool of qualified participants. Clark, Feldon, and Yates (2011) suggest using three or four experts during a CTA study in order to maximize efficiency and accuracy while Clark et al. (2008) suggest using two or more experts when possible. This small sample size allowed the researcher an opportunity to go into depth with each participant. Creswell (2007) suggests minimizing the sample size in a qualitative study in order to go into "extensive detail about each site or individual" (p. 126).

Potential participants were located through the use of social media (Facebook and Twitter), Internet searches, or by referral. Requests to participate in this study were sent to several National Board Certified Teachers (NBCT) Facebook groups. A pool of over 30 potential participants responded but only expert one fulfilled the requirements of expertise for this study. Expert two was located through a referral from a central office supervisor of a large school district. Expert three was located through a series of direct emails sent to NBCT as located by a search on the Internet. The final expert was located through a referral from TIE one. All of the novice participants were located by referrals of professional acquaintances of the reseracher. Novice participants were contacted through email.

Since expertise is highly contextualized, teachers participating in this study were all upper elementary classroom teachers. This is the student population most familiar to the researcher.

Four of the teachers were novice teachers. For the purposes of this study, novice teachers were defined as teachers who have completed one school year of teaching but have not yet completed their third year. This requirement helped to ensure novice teachers had enough experience to be interviewed on how they planned to use technology for instruction and were not overwhelmed with the demands of a new occupation as a first year teacher may have been.

The other four teachers were TIEs based on the definition of the researcher. Two criteria were used in order to establish a participant as a TIE for this study. First, each expert participant was an upper elementary NBCT who has taught the same grade level for three years or more years. The National Board Certification is a rigorous process that includes an initial screening, a portfolio, and an assessment (Harris & Sass, 2008). Berliner's (2004) research shows teachers who have become National Board Certified have an extensive pedagogical content knowledge and understand subject matter better than their peers. This qualification ensures participants are experts in both pedagogy and content knowledge.

Secondly, TIEs also needed to be experts in technological knowledge. Participants were asked fill out The Measurement of Professional Expertise; Self-assessment questionnaire (Van der Heiden, 2000). The author of this instrument believes it "may be useful as a means of identifying professional expertise and expert performance" (Van der Heiden, 2000, p. 30).

The Van der Heiden instrument (2000) is a self-reporting tool that can aid in the identification of expertise regardless of domain. This instrument measures expertise in five dimensions; knowledge, meta-cognitive knowledge, skills, social recognition, growth, and flexibility. This instrument has been shown to have reliability coefficients of 0.83 and higher when used to self-report and 0.93 and higher when used to rate an employee by a supervisor in all five domains.

Although a few instruments have been designed for specific use with TPACK, none of these instruments were used for this study. The TPACK instruments were not specifically designed to show expertise, only competency. The National Board Certification does not measure knowledge of technology integration, thus requiring the use of an additional tool. For these reasons, the Van Der Heijden (2000) instrument (Appendix A) was used to satisfy the technology integration part of the TIEs.

All potential participants were required to complete open-ended screening questions created by the researcher asking them to detail a remarkable lesson using technology (see Appendix B) which were scored on a rubric (see Appendix C). This provided the researcher a quantifiable way to select the most qualified participants.

Table 1

Participant Characteristics

Participant	Position	Highest degree	Years of experience	Years of experience using technology	Subjects taught
Expert 1	4th grade	2 Bachelor	26	21	all
Expert 2	3rd grade	Specialist	30+	4	all
Expert 3	4th grade	Doctorate	26	5	language arts
Expert 4	4th grade	Master	17	9	all
Novice 1	5th grade	Bachelor	1	1	all
Novice 2	5th grade	Bachelor	2	2	language arts
Novice 3	5th grade	Bachelor	1	1	language arts
Novice 4	6th grade	Bachelor	1	1	science

Research Design and Procedures

For this study, a Cognitive Task Analysis (CTA) Framework was utilized (Crandall et al., 2006). CTA provided an objective and systematic way to research expertise in this domain. Crandall et al. give the following reasons to use CTA to study expert performance:

> The researcher or practitioner carrying out a CTA study is usually trying to understand and describe how the participants view the work they are doing and how they make sense of all the events. If they are taking effective action and managing complex circumstances well, the CTA should describe the basis for

> their skilled performance… Cognitive Task Analysis studies try to capture what people are thinking about, what they are paying attention to, the strategies they are using to make decisions or detect problems, what they are trying to accomplish, and what they know about the way a process works. (2006, p. 9)

CTA methods focus on "describing and representing the cognitive elements that underlie goal generation, decision making, judgments, etc." (Militello & Hutton, 1998, p. 1618). Typically, the bulk of data in a CTA study is based on in-depth interviews with subject matter experts. These interviews have the ability to gain information on situation assessment strategies, identification and interpretation of critical cues, metacognitive strategies, and important perceptual distinctions to name a few.

Data Collection Process

The interviews included in this study followed the Critical Decision Method (CDM) procedure (Crandall et al., 2006). "The CDM is an intensive interview that often takes as long as two hours" (Crandall et al., 2006, p. 72). During the CDM, the researcher is attempting to identify an incident and critical memories about it. Through this procedure, a researcher is attempting to understand why the participant made certain decisions during this incident from the perspective of the participant. These insights may lead to an understanding of situations where the interviewed experts had pivotal experiences in their development.

Interviews were conducted through Skype or the phone for all participants. This allowed both the participants and researcher a convenient way to communicate and also allowed the researcher a way to interview participants regardless of location. All interviews were recorded as a way to preserve data.

A streamlined version of the CDM procedure is the applied cognitive task analysis, or the ACTA interview (Militello & Hutton, 1998). The ACTA interview is a specialized CDM procedure. The ACTA interview was designed for a situation very similar to this study; a way for a novice researcher to complete interviews using a CDM strategy comparing expert performance to the performance of novices. The same ACTA interview protocol was used for both expert and novice teachers.

After identification of participants, data for this study were collected in three interviews as outlined by the ACTA interview model; a task diagram, a knowledge audit, and finally a simulation interview. Each of these interviews happened in separate sittings.

The first interview in this study was the creation of a task diagram (Militello & Hutton, 1998). The task diagram (Appendix D and E) provided a broad overview of the task and identified the most difficult cognitive elements of the task (Militello et al., 1997). These cognitive elements could result in decisions or physical actions. The purpose of this diagram was to gain an overview of the entire process; not to go into depth about each element. Each participant was asked how they planned for their most successful lesson that integrated technology. Participants were asked to break the planning of this lesson into three to six tasks. After the tasks were successfully identified, the participants were asked which of the identified tasks required the most difficult cognitive skills. At the conclusion of this interview, a diagram was created for each participant that showed the major tasks in the planning process when planning instruction using technology. The model also showed the task that required the greatest cognitive skill. This model served as a guide for the second interview in the study, the knowledge audit.

The second interview in this study was the knowledge audit. “The knowledge audit has been developed as a means for capturing the most important aspects of expertise while streamlining the intensive data collection and analysis methods that typify studies of expertise” (Militello & Hutton, 1998, p. 1621). A set of pre-created probes were used to have participants describe specific examples of domain knowledge (Appendix F and G). The list of probes served as a starting point for the interviewer. The goal of the interview was to find the nature of the skills, events where these skills were required, and specific examples of strategies that have been used. Participants were asked for specifics about each example in terms of critical cues and strategies that were used to make decisions during the discussed events. Finally, both groups of participants were asked what errors a novice may have made in the same situation.

The knowledge audit is not as extensive as the Critical Decision Method (CDM). Although it does not capture the depth of the CDM, “it does address a full range of aspects of expertise that are usually neglected by behavioral task analytic methods” (Militello et al., 1997, p. 3). This method provided enough detail to retain the context of the example.

The final stage of the ACTA interview was the simulation interview (Appendix H and I). In the simulation, each expert and novice was placed in a hypothetical situation where he or she was asked to plan a lesson integrating technology as a way to mentor a new teacher. The lesson was based on teaching either a math or reading lesson, based on the preference of the participant.

Each participant was asked to identify each of the major steps they would follow when creating this lesson. Each of these steps was probed in detail in an attempt to identify an assessment of each step, actions, critical cues, alternatives, and potential errors. During this interview, the researcher attempted to understand the judgments and decisions being made by each participant. “Identification and exploration of information surrounding high consequence, difficult decisions can provide a sound bases for generation of effective training and system design” (Militello et al., 1997, p. 4).

At the conclusion of all the expert and novice interviews, the researcher compiled all of the data into a cognitive demands table (Appendix J). The cognitive demands table includes columns with the following headings: cognitive demands, why difficult, cues, strategies, and potential errors. This table summarized the data from all of the novice and expert interviews.

Role of the Researcher

The role of the researcher during this study was to find suitable participants, and to collect and interpret data. Data collection was completed through the series of interviews conducted with participants. The collected data was shared with participants as a way to help ensure accuracy. Crandall et al. (2006) believe the role of the researcher in a CTA study it to choose the CTA methods most useful for their research. The researcher did not personally know or work with any of the participants prior to the study. During the interview process, the researcher did not take on either as emic or etic perspective, instead taking a viewpoint between the two.

The researcher has had training in both qualitative research and quantitative researcher during his coursework for this program. Additionally, he conducted a pilot study using the same methodology in order to become more familiar with it.

Pilot Study

Prior to collecting data, this study included a brief pilot study in order for the researcher to finalize interview protocols for each stage in the process and test the simulation interview scenario. This pilot study also allowed the researcher to become more familiar with the interview protocols prior to collecting data that would be used in the study. The researcher selected two individuals who completed the task diagram, the knowledge audit, and the simulation interview. All interviews were conducted over Skype and recorded. Results of the pilot study were not included in the findings of the study.

During the pilot study, the researcher learned some of the directions in the interviews needed to be clarified. The researcher also learned to better use probes to gain additional data. After conducting the pilot study, the researcher slightly changed some of the interview directions and probes.

Analysis of the Results

The first part of the ACTA process was to create a task diagram for each participant. During this phase of data collection, participants were asked to create a diagram containing the three to six steps they used when planning to integrate technology in an elementary classroom. Each participant was next asked to confirm the task diagram and to identify the steps that require cognitive skill. The task diagram served as an artifact for this part of the ACTA process for each participant.

The data resulting from the second part of the ACTA process, or the knowledge audit was placed into a knowledge audit table. Following the methodology suggested by

Miletello and Hutton (1998), three headings for the table were created; aspects of expertise, cues and strategies, and difficulty.

For the third part of the ACTA interview, the simulation interview, data was placed into a simulation interview table. Following the methodology suggested by Miletello and Hutton (1998), a table with the headings events, actions, assessment, critical cues, and potential errors was created.

Finally, the data from all of the interviews were placed into a cognitive demands table. Miletello and Hutton (1998) suggest using the cognitive demands table in order to "provide a format for the practitioner to use in focusing the analysis on project goals" (1998, p. 1625). By using a cognitive demands table, the researcher was able to focus on the most important parts of the ACTA interviews and not the more trivial details. The table helped to identify common themes present in the data and shows the differences between the TIEs and the novices. Following the methodology suggested by Miletello and Hutton (1998), headings created for the cognitive demands table were difficult cognitive elements, why difficult, common errors, and cues and strategies used.

CHAPTER IV

RESULTS

Introduction

The purpose of this study was to define common characteristics technology integration experts (TIEs) possess that novice teachers lack. In order to accomplish this task, four TIEs were compared to four novice teachers. The cognitive tasks involved in planning technology-rich lessons were carefully examined with each participant through a series of three comprehensive interviews. Each expert and novice teacher completed a task diagram, a knowledge audit, and a simulation interview. All interviews were conducted by the researcher through Skype or by telephone. The data recorded in all of the tables in this chapter are researcher summaries of what the participants said during their interviews and not direct quotations. In order to help verify the data, participants were asked to verify their data. Upon completion of the data collection process, the researcher synthesized the data taken from the participants to create a cognitive demands table for the experts and the novices. The two cognitive demands tables were compared to show differences in the cognitive tasks of TIEs and novices.

This chapter begins with an examination of the interviews conducted with the TIEs. First, the four expert task diagrams will be discussed, followed by the four expert knowledge audits, and then the four expert simulation experts. After the examination of the expert interviews, the novice interviews will be examined. As with the experts, the four novice task diagrams, followed by the four novice knowledge audits, and then the four novice simulation interviews will be discussed. Finally, the data from all of the interviews will be combined into an expert and a novice cognitive demands table. A discussion of the differences in the planning of experts and novices will finish the chapter.

Expert Task Diagrams

The following four task diagrams were created after interviews with the four expert participants in the study. Each task diagram was shared and approved by each TIE. The TIEs were asked to recall an exceptional lesson they taught that successfully used technology. Following the Militello and Hutton (1998) applied cognitive task analysis (ACTA) method, each expert was asked to identify three to six cognitive tasks required in the planning of their technology-rich lesson. Then, each expert was asked to identify the task that required the most expertise. The task requiring the most expertise as identified by the experts was more closely examined during the knowledge audits.

Expert One Task Diagram. During the task diagram interview (see Figure 3), expert one discussed how she planned a lesson where her students used various pieces of technology to create videos about the features of their new school. In small groups, students learned how to storyboard their presentation, create scripts, use various programs used for video creation, and create QR codes that would be placed by interesting or unique features of the new school. The QR code would bring up the video which would explain the school's feature and were placed in the proper locations around the school. Expert one spoke of the importance of modeling each part of the lesson, displaying step-by-step directions for each part of the assignment in the classroom, practicing the technology in isolation prior to the project, and review and problem solve as a whole group when necessary.

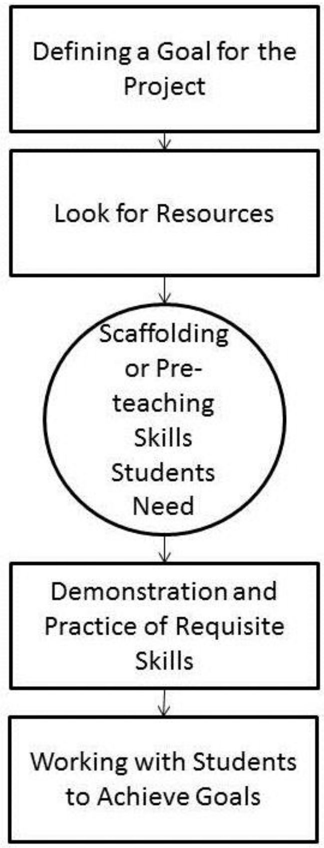

Figure 3. Expert 1 Task Diagram. Squares = tasks. Circles = tasks requiring the most expertise.

The task diagram from the first expert reflects that planning to teach a lesson successfully integrating technology contains five cognitive tasks. Expert one identified the third task, "scaffolding or pretaching skills students need," as the task requiring the most expertise. In the fourth task, students would demonstrate the requiste skills needed for the project in context, not in isolation as they practiced during the third task. Finally, the teacher would work with students to acieve their goals during the final task.

Although not a sepcific step in the task digram, the first expert frequently discussed the importance of carefully placing students in groups. Instead of just deciding on creating homogenous or hetorgenous groups, she considers the personalities of the students and the make-up of the group as a whole. For example, each group must have a leader but not a group of all leaders. She also stated that close friends should never be in a group together. Expert one also pointed out some children will choose to not work in a group and should never be forced to do so.

Additionally, the first expert thought it was imporant to have students review the work of their peers. This theme came up in many places in her task digram. This could be done in pairs, small groups, or in a whole group.

When conducting a group project, especially when technology is involved, the first expert believed in breaking tasks into the smallest possible chunks. These tasks should be shown through modeling and then practiced individually. She also suggested completing a pilot first in order to work out any potential problems.

Expert Two Task Diagram. During her task diagram expert, TIE two discussed a project where her students worked in small groups where they created an authentic project for social studies. Her students used iPads to take snapshots and videos and combined them to make a movie. Prior to using technology, students were asked to plan each step of the project. Throughout the lesson, the teacher and the students continued to work togther to learn the tehcnology and imnprove their projects in whole class and small gourp settings.

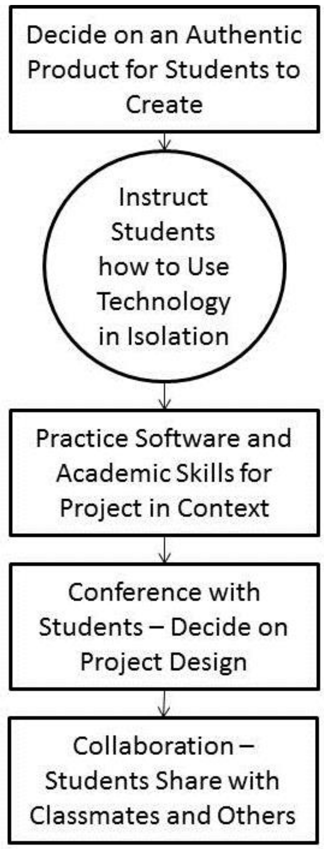

Figure 4. Expert 2 Task Diagram. Squares = tasks. Circles = tasks requiring the most expertise.

The task diagram for expert two was broken down into five tasks. Of the five tasks, expert two identified the second task, “instruct students on how to use technology,” as the task that required the most expertise. During the second task, students learned how to use technology in isolation and planned their project using a storyboard. During the third task, students practiced skills needed for the project in context. After practicing the academic and technology skills, students decided on the design of the project and began incorporating technology. Finally, students would collaborate and share their project with other students.

As with the first expert, the second expert placed an emphasis on students working with peers throughout the process. This process is often accomplished through the examination of student work in small groups or by the entire class. Throughout the course of a project, this expert believed that there are critical times where you must give students additional help when needed either individually, in small groups or in a whole class setting. Based upon this interview, an expert teacher is able to recognize these pivotal times and alter the lesson plan as needed.

Expert Three Task Diagram. Expert three choose to complete her task diagram (see Figure 5) based on a three week lesson where she created a vocabulary game for her students. Before the creation of the game, students were not prepared for their vocabulary quizzes and scores were typically poor. Expert three believed this was due to little parental support for home. This expert used multiple pieces of software to create an interactive, collaborative vocabulary game. Students competed is small groups against other groups. Each student was first responsible for answering each question presented. Then, each group would discuss the correct answer. This process provided each student much needed practice on all of the vocabulary words. Upon completion of this lesson, student scores on the vocabulary scores improved greatly.

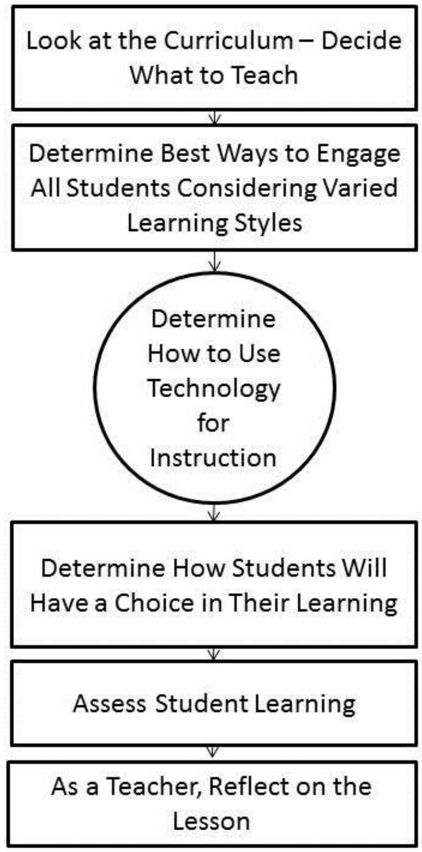

Figure 5. Expert 3 Task Diagram. Squares = tasks. Circles = tasks requiring the most expertise.

The third expert in this study created a task digram with six tasks. This expert chose the task, “determine how to use technology for instruction,” as the task that required the most expertise. After making sure she understood the curricular requirements of the lesson, TIE chose to make an assessment as part of the third task. This assessment helped to guide her instruction. Following the third task, TIE three determined how she would use the practice opportunities she created to help her students learn the curriculum. Finally, she would assess student learning and reflect on her lesson.

This expert is extremely limited by the resources available to her. She works in a school which teachers students from a low socio-ecomic group. Many of her students don't have access to technology at home as other students may. The school also has limited resources and little technology avaialbe for student use. Due to this limitations, she uses technology to fill in the gaps with resources her school district does not provide. Through the use of technology, her students are alotted time to practice individually and then to check their work collaboratviely. Students are able to get immediate feedback through the use of technology. This expert has seen an increase in student motivation and achievement after initiationing this process. Through the use of technology, this expert reports being able to differentiate her lessons and is better able to facilitate rich discussions with her class regardless of individual learning styles.

Expert Four Task Diagram. Expert four's task diagram (see Figure 6) was a decomposition of a persuasive writing lesson in which students reserached and typed their papers using technology. Expert four often spoke of the need to model each part of the lesson and how each task must be broken up into the smallest possible unit available. This included both acadmic and tecnological tasks.

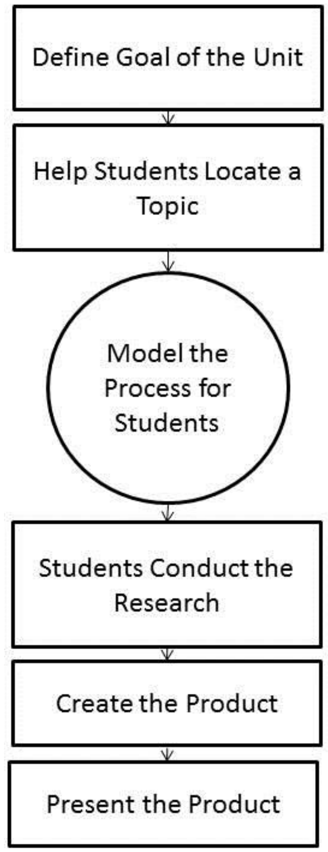

Figure 6. Expert 4 Task Diagram. Squares = tasks. Circles = tasks requiring the most expertise.

Expert four created a task digram with six tasks. Of the six tasks he identified, the third one, “model the process for the students,” was the task identified as requiring the most expertise. TIE four began the third task be locating appropriate resources. Then, he would show how the students would learn how to use technology in isloation. This task included him modeling the technology for the students. Next, he showed students how information was orgainized in nonfiction materials. Then, he conducted a close reading of the resources. He pointed out to students how to find the important information in their resreach. Finally, he showed the students how to paraphrase their findings. After modeling the process for his students, TIE four had the students conduct resreach, create their product, and present their product to their classmates.

This expert put an extreme emphasis on modeling. He emphasized the need to break down each part of the process the smallest possible task. This is true of both academic and technological steps. Each step must be modeled and then practiced in isolation. According this TIE, this step-by-step approach ensures maximum student learning.

Expert Knowledge Audits

As consistent with the Militello and Hutton (1998) methodology, after completion of the task diagram, the researcher conducted a knowledge audit with each expert. This knowledge audit probed the task the expert identified as requiring the most expertise during the task diagram interview. Every effort was made to have the expert explain why he or she made each decision and what possible mistakes a novice may make. This was the most in-depth part of the data collection process.

Expert One Knowledge Audit. During the knowledge audit with the first expert, the expert was asked to explain in detail the task she identified as requiring the most expertise, instruct the students on how to use technology. She spoke of the need to have a clear plan in all aspects of the lesson including what skills to model, how to place students in groups, and remaining flexible in the lesson. She thought novice teachers often lacked flexibility, assumed students knew how to do things they did not, and often moved forward regardless if students mastered skills or not.

Expert one often spoke of the need of being flexible. She sugested writing lesson plans in pencil and not pen, allowing them to be changed easily. According to expert one, a skilled teacher will know when his or her students are understanding and when he or she needs to stop, get the class back together to retaeach.

The first expert also spoke of some common mistakes novice teachers make. Other than not being flexible, she believes novice teachers are afraid to let students fail. Sometimes, novice teachers are so afraid of letting students fail, they will actually do the work for them. Instead, she believes students can learn from their mistakes and sometimes failure is a neceassary step in the learning process.

Table 2

Knowledge Audit for Expert 1

Task of Interest – Instruct Students on How to Use Technology			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Perceptual Skills (Judgements TIEs make about planning a technology-rich lesson novice teachers cannot)	Expert teachers can more correctly gauge the technology skills of students Storyboard the lesson first – just like a cartoon	Novices make incorrect assumptions about the technology skills students already have Novice teachers want to go straight to the technology part and not storyboard the lesson first Novice teachers don't always have a plan for the entire lesson.	Practice project to get the most important requisite skills (pilot) Do not jump right into the main lesson Practice requisite technology skills in isolation Understand the technology parts – how things work

Task of Interest – Instruct Students on How to Use Technology			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Anomaly (Occurrences during instruction TIEs predict during planning novice teachers cannon predict)	Have a clear plan - without a clear plan, students will spin their wheels Allowing students to fail can be a very important lesson	Novice teacher may not let a student fail Novice teachers don’t always hold students accountable Novice teachers aren’t always patient enough	If a student must fail, try to make it early in the process; students may be more willing to listen after learning this lesson Conference with students to check on their progress When students aren’t listening and attempting to forge ahead, you can hold them accountable by taking a quiz When students struggle, discuss with the students through conferencing what was needed from the lesson for the student to be successful Accountability - when students learn they are being held accountable, they are much more willing to learn along with their classmates Allowing a student to learn from their own mistakes is important You must wait until the students are ready to talk -be patient.

Task of Interest – Instruct Students on How to Use Technology			
Area of Expertise	**Example**	**Why Difficult**	**Cues & Strategies**
Past & Future (TIEs can predict student difficulty where a novice teacher may not)	Consider the personalities of students more so than their abilities when creating groups High powered students, not leaders want to be the whole show - be careful placing these students Use homogenized groups Look at strengths of all students when considering their placement Some students must work alone (not common) Look for transition points in the project and consider carefully Use different ways to learn - physical and pencil and paper	Novice teachers would look at just ability of students and not consider other factors when creating groups Novice teachers may allow best friends to work together or may allow students dependent on other students to always work together Novice teachers want to fix everything themselves A student failure is their failure - a failure of the teacher. Novice teachers want to rush in. They are not patient Novice teachers work on timelines and deadlines, not the learning of students Novice teachers aren't flexible after the original plan Novice teachers are focused on teaching standards, not students Novice teachers don't acknowledge students must learn lower steps before reaching higher steps Novice teachers place an	Look at beginning of the year - usually a kid that withdraws and doesn't do anything will need to work individually Don't put best friends together A student can sometimes become dependent on another student - limit their access to that student when creating groups. Experienced teachers use their gut feelings and experience - some things just can't be described A kid that isn't participating is usually lost, not bored as it may appear Remove the threat of the student being wrong Put down the planned lesson for a day or two and come back to it – it's like proofreading your plan Facilitate student learning, don't teach standards Write lesson plans in pencil, not ink Don't teach just the curriculum - this doesn't acknowledge what

Task of Interest – Instruct Students on How to Use Technology			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Big Picture (Indications a novice teacher does not understand the pig picture when planning a technology-rich lesson)	Novice teachers go right to the technology and they don't remember the pre-steps	Novice teachers grew up using technology – they think everybody should go forth using technology Students need to know all the stages – use concrete	Start with vocabulary - hard to do with technology Use concrete manipulatives. - don't skip past the concrete stage
Improvising or Noticing Opportunities (Differentiation planned for a specific student or students)	Think of specific students to differentiate for	New teachers are frustrated easily when students struggle; they can't predict where students may struggle Teachers have to try new things which may result in the teacher failing - you have to allow yourself to fail Novice teachers think they know everything	Look for student strengths and their learning styles - play to those strengths when planning lessons.

Task of Interest – Instruct Students on How to Use Technology			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Self-monitoring & Adjustment (Changes apparent to the planning of the lesson after it was taught)	Teachers need to give control of learning to the students as soon as possible	A novice teacher wouldn’t understand the difference between doing it yourself and doing it for your students Novice teachers don’t always allow students to take ownership - instead, they guide students to their idea of a project and not let the students create it	Give responsibility to the students Always consider - what are you doing, why are you doing it, and how are you doing it - how do these affect student learning

Expert Two Knowledge Audit. During the knowledge audit with the second expert, the expert was asked to explain in detail the task she identified as requiring the most expertise, instruct the students on how to use technology. She placed an emphasis on modeling each part of the lesson, always starting with storyboarding the assignment, especially when using technology. This expert also frequently discussed how she views the role of technology. She believes technology should be used to create a product and to facilitate student collaboration for students, not just for practice of discreet skills. Expert two also spoke of the need to frequently adjust lessons as you go along based on any difficulties the students may be having.

The first two experts had many similar ideas present in their knowledge audits. First, both of these experts referenced lessons culminating with authentic tasks. When creating these authentic tasks, both of the TIEs had similar ideas of how to group students together. They believe that working in groups can be of a substanial benefit to students and that technology can aid student colloboration. Expert two spoke specifially of how technology can be used for student collaboration. Both of the TIEs spoke of the importance of storyboarding the lesson, soemthing they felt could be missed by novice teachers. Finally, both TIEs discussed the need of being flexible during the process. They both believe that at some point in the process, students may need to be brought back to troubleshoot a problem or reteach a skill students are struggling with.

Table 3

Knowledge Audit for Expert 2

Task of Interest – Instruct Students on How to Use Technology			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Perceptual Skills (judgements TIEs make about planning a technology-rich lesson novice teachers cannot)	Modeling the expectation of the outcome of the lesson Talk about what should be included (rubric)	May be more concerned with grading instead of helping a child be successful – they look at the final product instead of looking at the process They don't use the process as a teaching tool – novice teachers aren't flexible Already have preconceived notions	Use writing frames – show step by step Give examples It's ok to stop and have students share a solution to a problem Have students show how to use technology
Anomaly (Occurrences during instruction TIEs predict during planning novice teachers cannon predict)	Students may not understand the assignment at the beginning - may need more guidance	Not prepared if something doesn't work Trained to prepare, teach, and grade a lesson Not prepared to go back and reteach	Don't be afraid to stop and say this is not working Every lesson will not go as planned Figure out where the problem is

Task of Interest – Instruct Students on How to Use Technology			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Past & Future (TIEs can predict student difficulty where a novice teacher may not)	I don't always know I have to be aware – pay close attention. Be willing to step in and help Must be able to detect during instruction, not always in planning part Must storyboard the project	More interested in the product - the process is more important Must have a plan more than just the end in mind	Look at the whole process as a learning experience Storyboard the project, don't look at just the end Do the planning
Big Picture (Indications a novice teacher does not understand the pig picture when planning a technology-rich lesson)	Use technology to learn – it is a resource Students use it to communicate and collaborate with others Use for authentic projects - I want them to have a real world purpose	It takes too much time to have students collaborate with teach other Novices don't see the value in authentic assignments Novice teachers are more interested in assigning grades to students than creating meaningful learning experiences	Create authentic projects Find things to foster communication and collaboration

Task of Interest – Instruct Students on How to Use Technology			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Improvising or Noticing Opportunities (Differentiation planned for a specific student or students)	I would sit by these students and guide them I would work through it together with them Give them more guidance with their plan (either me or a peer	Novice teacher would assume lower students couldn't I would wait until a student has trouble and then help them	Wait to see what they can do before stepping in to help Be close by to help Ask other students for help
Self-monitoring & Adjustment (Changes apparent to the planning of the lesson after it was taught)	I would have done smaller segments I would have broken it up into more manageable steps Better plan for the parts I know they would struggle with	Novices think you tell them one time and they will have it	Use frequent check ins Plan smaller pieces Writing out on a chart helps for certain procedures Have students evaluate where they are in the process

Expert Three Knowledge Audit. The knowledge audit for the third expert focused on the task she identified in the task diagram that required the most expertise, determine how to use technology for instruction. This expert spoke frequently about how to groups students appropriately when using technology, something she believes novice teachers struggle doing. Instead of grouping students only according to ability, teaehers should consider a wide variety of factors including personalities of individual students. She also believes some students work best alone. Expert three also spoke of the importance of reflecting on lessons. This will help teachers improve their lessons and provide better instruction for students.

As with the other experts, expert three spoke at length about how to split up with students. Both expert one and expert three believes some students will prefer to work alone and should not be required to work in a group. As with the first two experts, expert three believe technology can be used to aid in student collobartion. All of the first three experts agree student colloboration promotes student learning.

Table 4

Knowledge Audit for Expert 3

Task of Interest – Determine How to Use Technology for Instruction			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Perceptual Skills (Judgments TIEs make about planning a technology-rich lesson novice teachers cannot)	I can read current level of students better I can create a lesson for areas students struggle in Experienced teachers have more tools in their toolbox to use I can better develop lessons to keep kids engaged	Inexperienced teachers are overwhelmed with teaching curriculum Inexperienced teachers must learn classroom management (something that is trial and error) New teachers don't many tools in the toolbox New teachers must learn school rules and build new relationships New teachers must also must learn district and state standards There is an intimidation factor with working with new teachers New teachers are moved to other grade levels almost every year	Spend 30 minutes observing other teachers, spend 30 minutes writing up what we saw - three steps - Reaffirm 3 things I want to integrate into my classroom - 3 observations (takeaways) Use team meetings to help with problem students. New teachers should collaborate with other teachers that teach same content. Use professional learning communities (PLC) Us e a mentor system - our district had a three year mentor program used in the district Use a NBCT mentor system -

Task of Interest – Determine How to Use Technology for Instruction			
Area of Expertise	Example	Why Difficult	Cues & Strategies
			novice teachers would have the same mentor for 3 years Have mentors in the building
Anomaly (Occurrences during instruction TIEs predict during planning novice teachers cannon predict)	I have more knowledge of the students Knowing how to group students (don't mix vinegar and baking soda)	Novice teachers are too engrossed getting everything else (curriculum) figured out A novice teacher may not know to separate students	Reflect on a lesson after you give it – especially after a unit assessment Do an item analysis - why did students miss certain questions? Place sticky notes in the lesson plans with changes for next year
Past & Future (TIEs can predict student difficulty where a novice teacher may not)	I have taught this lesson several times - I knew where students would have difficulty	Student teachers would not have the experience to know where students may struggle	Reflect each day to help refine your teaching
Big Picture (Indications a novice teacher does not understand the pig picture when planning a technology-rich lesson)	When I watched the groupings – how did the teacher create the groups? Knowing where to put the students – make-up of the teams and knowledge of the students	Novice teachers can't read students as well (especially at the start of the year) Novice teachers don't understand how to read Lexiles - they don't know how to read data Novice teachers want to be	Group by Lexile (ability)– Understand differences between students (gifted and special needs) Sometimes let them pick their teams (competition)

Task of Interest – Determine How to Use Technology for Instruction			
Area of Expertise	Example	Why Difficult	Cues & Strategies
		students' friends – students are running the classroom	Draw sticks Consider the type of lesson – for a review groups don't matter as much Consider ability more with new content
Improvising or Noticing Opportunities (Differentiation planned for a specific student or students)	Put question on screen – I read the question out load for students who have reading difficulty Allow loners to work alone if they need that Allow student to work together to learn	New teachers rely too much on the teacher's manual New teachers don't know a curriculum Novice teachers don't always know when to stop and reteach New teachers don't always have the same work ethic and commitment as veteran teachers	Reflect Know your students – build relationships Spend time learning your curriculum

Task of Interest – Determine How to Use Technology for Instruction			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Self-monitoring & Adjustment (Changes apparent to the planning of the lesson after it was taught)	Technology glitch – I used students to fix this problem Some of my sentences were too long – use short and concise lessons I made a note for students that struggled to help me teach the lesson (for next year) I learned students loved the technology	Novice teachers don't reflect on lessons – day to day survival only No time to focus	End of the day – take 10 to 15 minutes to debrief your day – what worked – what didn't work Are we ready to move on? Veteran teachers eat and breathe school Make sure kids are prepared for the future

Expert Four Knowledge Audit. During the knowledge audit with the fourth expert, the expert focused on the task from his task diagram “model the process for students.” This expert spoke repeatedly about the importance of breaking down the lesson into the smallest possible parts and then modeling each of these for students doing a think-a-loud. This was idea was certainly discussed by the other experts, but not in the same detail as this expert. He believes novice teachers often struggle with this step based on time. Since time is limited, novice teachers must foucs primarily on learning the content and they just do not have the time to plan the teaching of the lesson, igonoring the fact that each step must be broken down into as small as segments as possible.

Although not to the extent of the fourth expert, both expert one and two frequently spoke of the importance of modeling each task and breaking down the lesson into the smallest possible tasks. Expert four frequently spoke of the need to work individually with students who may be quiet or have attention issues. He gave several stratgies for helping these at risk students.

Table 5

Knowledge Audit for Expert 4

Task of Interest – Determine How to Use Technology for Instruction			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Perceptual Skills (Judgments TIEs make about planning a technology-rich lesson novice teachers cannot)	Break down the lesson into smaller and smaller pieces Model the process for students – both the academic skill and the technology skill	Novice teachers assume too much based on abilities of just a few students	Don't forget the technology skills – show students how to move the cursor and how to double click Avoid making assumptions Break down each task to its lowest basic level Don't just listen to the loud voices – remember the quiet ones
Anomaly (Occurrences during instruction TIEs predict during planning novice teachers cannon predict)	I plan a visual aid to help students with potential pitfalls	Novice teachers teach the way they learned instead of thinking about their students	Students learn in many different ways Break down your lesson into very fine points Map down exactly how you think your lesson will go

Task of Interest – Determine How to Use Technology for Instruction			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Past & Future (TIEs can predict student difficulty where a novice teacher may not)	I know my students and I know what they struggle with based on my relationships with them Sit with a student individually who may struggle Remove distractions from students who have attention issues	Teaching is hard Too many things for novice teachers to think about Novice teachers focus on content	Recognize patterns in your data, observations, and your actions After a week or two of school, get a class list and write general comments about each student - do this occasionally to ensure you know your students personally
Big Picture (Indications a novice teacher does not understand the pig picture when planning a technology-rich lesson)	If the novice teacher couldn't articulate exactly what they wanted the students to know at the end of the lesson	Teaching is hard Novice teachers will be focused on how they deliver the content and not on student learning Experienced teachers just know what to do naturally	Do some backwards planning - standards to unit plan to weekly plan to individual plan
Improvising or Noticing Opportunities (Differentiation planned for a specific student or students)	Give some students a sentence starter Narrow topics for students while still giving them a choice (give them four topics instead of just letting them choose)	Time – it takes too much time for a novice teacher to differentiate - I already know to do this	Use a sentence starter Provide novice teachers with resources

Task of Interest – Determine How to Use Technology for Instruction			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Self-monitoring & Adjustment (Changes apparent to the planning of the lesson after it was taught)	Work harder at finding resources for students I didn't differentiate enough I didn't model the graphic organizer clearly enough	All teachers may not take time to look at the student data and work	Look at data from students Think about the level of student engagement Make sure students have enough background knowledge

Expert Simulation Interviews

The final interview with each participant was a simulation interview. This is consistent with the Miletello and Hutton (1998) ACTA methodology. Each expert was placed in a scenario where he or she was asked by a principal to help a first year teacher plan a lesson. The expert was asked to break down the planning of this lesson into three to six steps, just like the task diagram. Unlike the knowledge audit, each expert was asked to give the rationale for making each decision. By asking the expert to explain each decision, insight on why experts make certain decisions was gained.

Expert One Simulation Interview. The first expert was asked how she would help a new teacher plan a common core fourth grade math lesson dealing with fractions. She decided to decompose the planning of this lesson into five steps. This expert suggested that using technology in each step should not be done. She believes the introduction of the lesson should be taught with manipulatives, using no technology, and as students develop a better understanding, technology can be incorporated into the lesson.

Table 6

Simulation Interview for Expert 1

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Identify vocabulary using a model	Ground work – communicate in math language	Start on white board – name the parts of a fraction – how many total parts	Students can't move forward without it	I could send out using technology – using Google Docs Label the parts of a fraction using technology	Going too fast
Model a very simple problem using manipulatives	Application of vocabulary – showing the flow of the problem Students must have a physical connection	Have students model using manipulatives first After students model with manipulatives, then have them go to a pictorial representation	Experience Make it real world, give the students application to better understand the problem	No - modeling is better done without the use of technology	Not using equal pieces to represent fractions Fractions must be equal

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Have students model simple problems – may use technology	Reverse learning – if they understand the process – they should be able to model – the synthesis step	Move around a lot – get to every kid Don't rely on shouting answers or group answers - take the time	You can see confusion in later work I know some students need more work than others - you must interact these students	I can't think of any	Getting too complex too fast Keep it simple a little longer Create and share problems Do repetition without punishment
Create and decompose problems in pairs	More guided practice tending to individual practice Strategic grouping can really help	Lots of being available Listen instead of telling Students must do the work, not the teacher	Experience – when I go too fast I miss some	Using the Chromebooks or laptops or a computer lab Show models on the overhead	Talk too much and not listen enough Keep rigor high

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Share together using technology	Look for a-ha moments from the students Some students may be reluctant to share - remember them Other students may be wrong - don't forget about them Show both correct and incorrect answers	Give students lots of support I would remind class of our class rules – gracious professionalism Share student knowledge	I've been the kid that has been wrong - Put yourself his or her shoes	Use technology to share student work	May not correct student mistakes – may only show correct answers from students Novice teachers don't always allow students to make mistakes

Expert Two Simulation Interview. The second expert was given the same scenario as the first expert; helping a new teacher plan a fourth grade common core lesson at the request of her principal. Expert two decided on creating five steps for the lesson. As with the first expert, she believed students should use actual manipulatives when starting this lesson. Unlike the first expert, the second expert thought the use of technology from the first step in the lesson could be beneficial. She suggested taking screen shots of the work students were doing with the manipulatives as a way to catalogue their work and use as examples later if needed.

Table 7

Simulation Interview for Expert 2

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Introduce the lesson with pattern blocks	See the relationship between the unit fraction and the whole Also, the manipulative represents a real image	Find materials Helping her organize and group her lesson	Children developmentally need to start with concrete and move to symbolic	Take screenshots of what they did - label with kid collage	Not having students use manipulatives. You can't have three halves
Use app Pattern Shapes – show them how to use the basics and then have them explore – come up with different fractions	See different ways unit fractions – what it is and how it combines to make the whole or more than the whole	Have students determine what would make a whole I would show them how to label the fractions I'd bring in vocabulary. I'd let them share their work with the class	Through training I had – Math endorsement – on line trainings – summer class through Vanderwal Other than college training. Continue to learn Learned from past experiences	Modeling using a Smartboard or the document camera Modeling is important Using videos from websites like Learnzillion	Wouldn't show them the very basics of the app Not giving students time to explore Telling them what to do

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Give them problems to do using the app – take screenshots	Check for understanding Do they have an understanding of unit fractions and what makes a whole?	Have students take a screen shot of their work and labeling	You must check if they understand before you assess I learned it from prior experience Reteach if students still struggle		Inexperience teacher may not know about three halves, teacher may say it is wrong
Explain thinking using an app (Notability or Educreations)	Have children use written expression Not following a rote way of doing it and communicate with others	Use the app to submit a written explanation of the problem to the teacher	Students learn from others Prior experience Need visual models	Use the document camera with dongle cord Share with Edmodo	Not giving students time to share Not letting students learn from their mistakes and resubmit
Share with other students using technology (Edmodo)	Give students an opportunity to see other solutions Grow from others	Have students share using technology Some students may choose to go back and revise	From past experience Looking at work, I expect them to correct it Continue to grow as a teacher	Sharing with Edmodo, Shadowpuppet, or Educreations	Not seeing the value of having students share Only use paper pencil test

Expert Three Simulation Interview. Instead of doing the same simulation as the first two experts, the third expert was hesitant to participate in a simulation planning a math lesson since she only teaches language arts. The expert and the researcher agreed that it would be more advantageous to have her participate in a scenario in which she could display her expertise. It was agreed upon that her scenario would be to help a new teacher plan a lesson on inferencing. Expert three brought up many issues novice teachers may have. For example, she thought it was important to model the task, practice together, and then have the students practice individually. She thought many novice teachers would not have students practice the skill individually.

Table 8

Simulation Interview for Expert 3

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Look at the curriculum – guide/map – whatever the district had – look at the key components	Determine what the district expects my students to know Look at what the students know ahead of time	Look at the curriculum guides – refer to resources to see if they were adequate	This is what the district expects me to teach Lack of resources	None	May not go through the whole scope and sequence Wouldn’t look at curriculum guides Teach straight from the basal

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Brainstorm some ways to deliver the lesson	Assess students I would try to get the new teacher to think of new ways to engage student learning This lets you know where the new teacher is in her experience Let the new teacher collaborate - allows her to bounce ideas off each other	I would make suggestions (flipbook) – introducing key terms Create a sample for my students I would model this with my students - I make a total of 4 flipbooks, one with each class Provide examples for my students	I know students are visual and kinesthetic learners It also works with auditory leaners I know this from my past experience	Could use the Smartboard – use the shade technique- to reveal the answer Use during the review part of the lesson and incorporate technology Use Teachers Pay Teachers to find resources Website from American Federation of Teachers	Would not make the examples - it may not work if you didn't do it yourself ahead of time You may miss a step

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Create a Smartboard lesson – a memory type game (definitions and then examples)	Integration – trying to reach kids Think of a guided lesson to provide practice for students	Create the lesson with the teacher Practice using the technology	You are the one who is supposed to be the expert. You must only provide accurate information Find examples of a misconception Create a strong foundation	Could use a Kahoot, an interactive web-based game	Not breaking it down into small enough steps Not knowing their students well enough
Pull examples from text	Trying to show students how these words in definition look like in context	Whatever resource, as we read we are looking for a simile or metaphor We would share out as a group Highlight and label in the text	Things must not be taught in isolation - must be taught in context	Put up a passage on the Smartoard or do a freeze frame with the document camera – highlight the passage. Put headings on the Smartboard and do a scavenger hunt Provide a student example in a student writing	A novice teacher may not take it into an independent stage A novice teacher may not go back and adjust the lesson Reflect upon you as a teacher

Expert Four Simulation Interview. The last expert participated in the same simulation as the first two experts. As with his task diagram and knowledge audit, he frequently spoke of the importance of breaking up a task into the smallest possible part. As with the with the first expert, expert four decided there were times when the use of technology was not desired, instead focusing on the use of manipulatives with his students. As with the first expert, using technology can occur after students have a basic understanding of the concept.

Table 9

Simulation Interview for Expert 4

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Think about what you want the students to know – the goals	There is an end in mind	Break out the standard, look at the resources	Through the National Board Certification	None	Not knowing the standard
What is the exit ticket for the lesson?	Find resources to show mastery	Locate the resources or create them	I want to know that kids can show me	Finding online resources that could help	Not having this step
What do we know that they know already?	Start with something familiar – learning with similarities Don't start off with something complicated	Start with something they already know to keep students engaged – keep them confident Pump them up	Experience	Probably not	Not doing this step – jumping right into the complicate stuff
Teaching the lesson	I am going to teach something new – explicitly say you are teaching something new	Show images Have the teacher know exactly what they are going to model Gradual release – Work independently or in small groups	Training – in-service	Use visual manipulatives Online games for practice	Not being able to break it apart into discreet parts

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Formative assessment	Do the students understand – I want to see their brain on the paper – I want to see their thinking	Make it a priority Put out problems that they need to model it Have them write what they know, what they need to know	Not sure – seems ingrained into me Very much experience	None	Having only lines for the answer Not using the correct language No feedback

Novice Task Diagrams

The following four task diagrams were created after interviews with the four novice teachers who participated in the study. As with the experts, the protocol for each interview followed the Militello and Hutton (1998) ACTA protocol. Upon completion of the task analysis, each task diagram was shared and approved by the novice. As outlined by the Militello and Hutton (1998) methodology, the he novices were asked to recall an exceptional lesson they taught that successfully used technology. Each novice was asked to break down the planning for this lesson into three to six tasks. Then, each novice was asked to identify the task that required the most expertise. The task identified as requiring the most expertise was more closely examined during the knowledge audit.

Novice One Task Diagram. Novice one’s task diagram (see Figure 7) was based on a lesson she taught her class. This lesson was based on each student creating a Facebook like profile for important individuals during the Civil War.

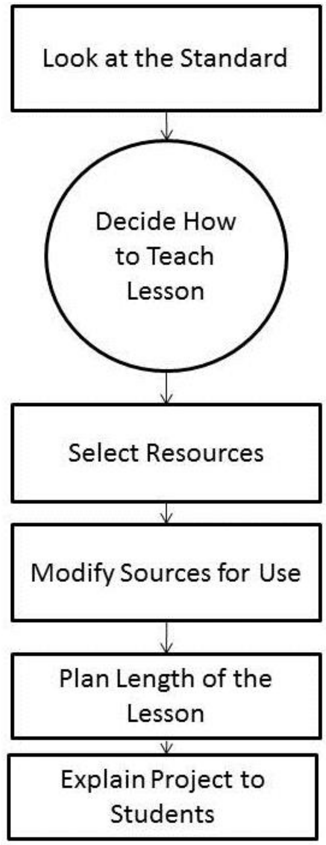

Figure 7. Novice 1 Task Diagram. Squares = tasks. Circles = tasks requiring the most expertise.

The first novice created a task diagram with six tasks. Of the six tasks, the second task, “decide how to teach the lesson,” was the task identified as needing the most expertise. After considering the prior knowledge of her students and collaborating with more experience teachers on her team as part of the second task, novice one selected the resources to use in her lesson as her third task. After completing task three, novice one modified the selected sources, planned the length of her lesson, and finally explained the project to her students.

This teacher spoke of the importance of modeling each step along the way for the students. She believes teachers incorrectly assume students know how to correctly use technology and often forget the small steps. She modeled details such as how to correctly save a project and how to turn in the assignment to the teacher.

Novice Two Task Diagram. For his task diagram (see Figure 8), novice two referenced a lesson where students used his class blog to locate and complete posted class assignments. Using iPads to complete the assigned tasks, students were placed in groups by ability and given links to give instruction prior to completing their tasks.

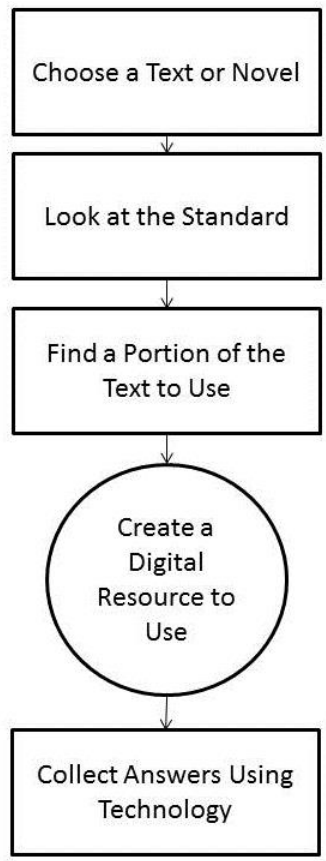

Figure 8. Novice 2 Task Diagram. Squares = tasks. Circles = tasks requiring the most expertise.

Novice two created a task diagram containing five tasks. Of the five tasks, he identified the fourth task, “create a digital resource to use,” as the task that required the most expertise. In order to complete this task, he located powerful reading passages that allowed students an opportunity to easily practice the skill being instructed. Finally, novice two collected answers from the students using technology.

The second novice teacher discussed how he creates digital resources for his students to use. Through these resources, he is able to determine if students have mastered concepts or if they need additional practice. He also spoke of the importance of modeling how to use the technology, even tasks as basic as how to turn in a digital assignment.

Novice Three Task Diagram. During her task diagram (see Figure 9), novice three referenced a lesson used with her class that involved Glogster, a website students can use to make interactive multimedia posters. Using Glogster, novice three students created book reviews that included opinion and summary writing.

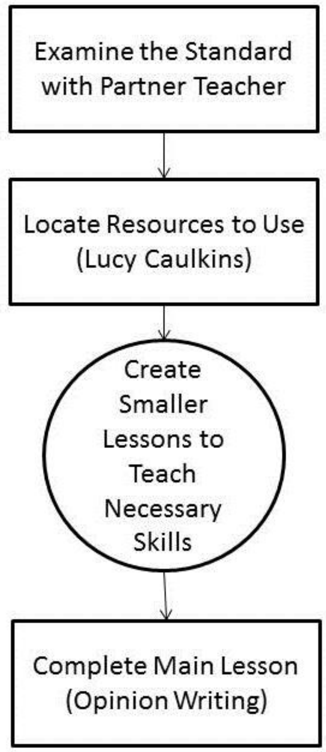

Figure 9. Novice 3 Task Diagram. Squares = tasks. Circles = tasks requiring the most expertise.

Novice three created a task diagram with four tasks. She identified the third task, “create smaller lessons to teach necessary skills,” as the task requiring the most expertise. During the third task, novice three taught students how to navigate the website, taught the format of the book review, had students research materials to add to the book review, and conducted a writer’s celebration. For the last task, novice three had students complete the main lesson.

The third novice teacher spoke of the importance of teaching the important skills in a smaller assignment prior to the major task. This would allow students to have practice on requisite skills before the main lesson.

Novice Four Task Diagram. For the task diagram for the fourth novice, novice four referenced a lesson where each of her students were assigned an element on the periodic table. Each student conducted research and completed a wanted poster for the element describing all of the important information of the element.

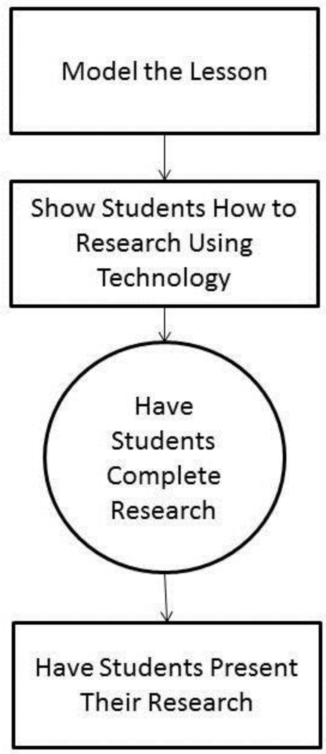

Figure 10. Novice 4 Task Diagram. Squares = tasks. Circles = tasks requiring the most expertise.

Novice four created a task diagram with four tasks. She identified the third task, “have students conduct research,” as the task requiring the most expertise. During the planning of the third task, she considered the behavior of her students and the logistics of the lesson. Finally, her lesson concluded with students presenting their resreach.

The fourth novice teacher spoke of the the difficulty of having limited technology in this lesson. She only had access to three computers. She said it was difficult rotating students throguh these computers while keeping other students engaged.

Novice Knowledge Audits

In the same manner as the experts, after completing the task diagram, each novice teachers completed a task diagram consistent with Miletello and Hutton (1998) methodology. The task each novice identified was closely examined during the task diagram as a way to identify the reasons the novices made the decisions they made.

Novice One Knowledge Audit. During the task diagram, the first novice identified decide how to teach the lesson as the task requiring the most expertise. During her knowledge audit, two themes were discussed several times. First, the novice teacher believed that new teachers lack experience that makes teaching more difficult. This was especially apparent when it came to classroom management and the curriculum. Secondly, newer teachers lack confidence more experience teachers possess. The possibility of this lack of confidence existing from a lack of experience is a distinct possibility.

Table 10

Knowledge Audit for Novice 1

Task of Interest – Decide How to Teach the Lesson			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Perceptual Skills (Judgments TIEs make about planning a technology-rich lesson novice teachers cannot)	Novice teachers lack experience - This makes it difficult Novice teachers often follow what experienced teachers do often without question	Lack confidence to question more experienced teachers Greater confidence comes with experience	Use different steps based on standards Look at materials Figure out the background knowledge each student already has
Anomaly (Occurrences during instruction TIEs predict during planning novice teachers cannon predict)	Questions about how to open documents and resave them Must show students the steps on how to do each part	Experience with taking online classes helped me with this	Make sure all the steps are laid out in the directions Everything is modeled for the students at the start of the lesson
Past & Future (TIEs can predict student difficulty where a novice teacher may not)	Differences in experience using technology between students	Novice teachers have a background of using technology and were taught these skills early on Assumptions are made technology skills were already taught	Give some students extra help or let them go on when they are ready – some students need more help Differentiate more

Task of Interest – Decide How to Teach the Lesson			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Big Picture (Indications a novice teacher does not understand the pig picture when planning a technology-rich lesson)	Look at the directions – the directions would be too vague and not have each step planned out	Assumptions made that students have access to technology at home	Plan instructional time so students can complete assignment at school to use resources
Improvising or Noticing Opportunities (Differentiation planned for a specific student or students)	No I did not differentiate this lesson - something I will do in the future	Still focused on the entire class – focusing on content Hard to focus on the differentiated piece	Flip the way you are planning the lesson - don't start with the standard Look at the students first and then plan Use a differentiation piece in your lesson plan
Self-monitoring & Adjustment (Changes apparent to the planning of the lesson after it was taught)	I will have student examples to use next year I will show more of the steps of how to use technology	Teachers know whether a lesson is successful or not but it isn't recorded well but teachers don't document this well	Use Planbook, an online lesson planning website, in order to have all your details saved

Novice Two Knowledge Audit. The second novice's interview took an in-depth look into the task he believed required the most expertise during his task analysis; create a digital resource to use. As with the experts, this teacher talking about the importance of breaking the steps of the project into smaller tasks, a practice he referred to as chunking. He also discussed the importance of teaching the technological skills in isolation, another theme prevalent in the knowledge audit of the experts. As with the first novice, he believed a lack of experience hindered the abilities of new teachers.

Table 11

Knowledge Audit for Novice 2

Task of Interest – Create a Digital Resource to Use			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Perceptual Skills (Judgments TIEs make about planning a technology-rich lesson novice teachers cannot)	The actual length of the lesson - what can students accomplish in 45 minute lessons	Novices have never taught before so they don't know the standards well enough to know pacing	Chunk assignments into smaller pieces Create times for each part of the lesson so you can keep track of how long the entire lesson takes
Anomaly (Occurrences during instruction TIEs predict during planning novice teachers cannon predict)	Technical errors – Internet down or hardware doesn't work - I can switch gears quickly	New teachers lack experience New teachers have no idea what might happen	Stay focused no matter what happens Have a clear outline where each student is Change groups if needed
Past & Future (TIEs can predict student difficulty where a novice teacher may not)	I knew what students would struggle with constructed responses	New teachers lack experience and can't recognize where students may struggle	Determine how many questions there are by how many questions marks in the response - Draw boxes for each box

Task of Interest – Create a Digital Resource to Use			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Big Picture (Indications a novice teacher does not understand the pig picture when planning a technology-rich lesson)	New teachers would get caught up with the technology and not the focus of the lesson	It's a new process for the teacher It is time consuming Takes experience to make it fluid	Focus on the content first Make sure things are user friendly Use a similar format to make things easier for the student Practice using the technology ahead of time
Improvising or Noticing Opportunities (Differentiation planned for a specific student or students)	A student was at a second grade reading level - needed to pull in additional resources for him to be successful	May not know to pull in materials at their grade level could help them understand 5th grade standards	Find passages at reading levels for the student but focus on the 5th grade standard Lower students will struggle at first but it will ultimately result in a better project
Self-monitoring & Adjustment (Changes apparent to the planning of the lesson after it was taught)	Spend more time teaching the logistical part of the technology	I can tell when students are getting frustrated - new teachers may not see this.	Teach the logistics in isolation first before teaching content

Novice Three Knowledge Audit. During the task diagram, the third novice identified create smaller lesson to teach necessary skills as the task requiring the most expertise. This teacher spoke frequently about classroom management and the need to create routines in order to maximize instructional time. Additionally, she suggested having a rubric outlining clear expectations would be of benefit to the students.

Table 12

Knowledge Audit for Novice 3

Task of Interest – Create a Digital Resource to Use			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Perceptual Skills (Judgments TIEs make about planning a technology-rich lesson novice teachers cannot)	I thought about students behavior, and attention span Can we do it in a smaller group or a whole group	Lesson involved a lot of attention – a lot of one on one attention Hard to designate helpers	Designate student helpers that can help with easy questions Have back-up lessons when using technology for when the technology doesn't work
Anomaly (Occurrences during instruction TIEs predict during planning novice teachers cannon predict)	Keeping everybody on task Have a schedule and a routine Lay down clear expectations and have it clearly displayed	New teacher get too wrapped in a lesson	Make time for routines Keep things as consistent as possible Break down the task into smaller steps
Past & Future (TIEs can predict student difficulty where a novice teacher may not)	The textboxes were very small in the website I used so I had students copy and paste - I found an easier strategy	New teachers may not try out the technology before teaching the lesson	Use technology first - go through the whole thing. Know where students may ask for help

Task of Interest – Create a Digital Resource to Use			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Big Picture (Indications a novice teacher does not understand the pig picture when planning a technology-rich lesson)	I didn't give expectations I didn't show finished product Show rubric	They would grade after everybody is done instead of doing it a little at a time during the project	Have a rubric and an example
Improvising or Noticing Opportunities (Differentiation planned for a specific student or students)	I thought about a student who was very slow for typing – used an app to read it to type it for him Behavior student with concern – I had him type it instead of writing it at first	Fairness – would want everybody to do the same thing	Think of end product Focus on the skill Be flexible with the medium - some students may be able to do more
Self-monitoring & Adjustment (Changes apparent to the planning of the lesson after it was taught)	Spend more time reflecting The project could have been broader – give students more choices Check out more iPads for student use	Novice teachers are just trying to get through the lesson - they don't take the time to reflect on their teaching	Reflection is easier when collaborating. Keep a journal and write on them each student

Novice Four Knowledge Audit. The fourth novice focused her knowledge audit interview on the task she identified as requiring the most expertise during the task diagram, have students conduct research. One of the concerns this teacher discussed was having difficulty using the computer lab. Since the computer lab was used for standardized testing for a great deal of time, she was only able to use her three classroom computers. As with the third novice, this teacher discussed the necessity of having clear expectations and issues that happened due to classroom management. She believes much of these errors occurred due to a lack of experience, a belief shared by many of the experts and novices in this study.

Table 13

Knowledge Audit for Novice 4

Task of Interest – Have Students Conduct Research			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Perceptual Skills (Judgments TIEs make about planning a technology-rich lesson novice teachers cannot)	Try to get the computer lab – plan ahead more	The computer lab was booked for standardized testing - only limited technology available in my room	Plan ahead more Try to find different technology to use other than just computers in the computer lab
Anomaly (Occurrences during instruction TIEs predict during planning novice teachers cannon predict)	Students would look for other things on-line not related to the assignment Students not on the computers would often be off task	Novice teachers would not know students as well - they don't know what they can do Not prepared for classroom management	More closely monitor what students are doing
Past & Future (TIEs can predict student difficulty where a novice teacher may not)	I knew students would have a tough time presenting – they don't much experience	Not having enough experience Student teaching does not help prepare new teachers enough	Go over the rules more clearly Create guided questions to help students research

Task of Interest – Have Students Conduct Research			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Big Picture (Indications a novice teacher does not understand the pig picture when planning a technology-rich lesson)	Not having clear rules using the technology	New teachers think it will go according to the plan - they don't know what to do when it doesn't	Plan for everything that you can Have clear rules for the students
Improvising or Noticing Opportunities (Differentiation planned for a specific student or students)	Group students by a benchmark test and continue to level Place in different levels, high with low, medium with medium.	New teachers would group them by ability and would not consider any other factors	Be flexible with groups Students should work with students of different abilities
Self-monitoring & Adjustment (Changes apparent to the planning of the lesson after it was taught)	I would have monitored behavior differently I'd have been more proactive with creating expectations to improve student behavior	Expecting it how they thought of it. Novice teachers think of the content first and don't consider the students first	Create steps for the process to help the student know how to proceed Create clear classroom rules to help student behavior

Novice Simulation Interviews

After completing the task diagram and the knowledge audit, each novice participated in a simulation interview. As with the experts, the simulation followed the guidelines of the Miletello and Hutton (1998) ACTA methodology. Each novice was placed in a hypothetical scenario where his or her principal asked them to help a new teacher plan a lesson using technology. The novices were asked to break the planning of this lesson into three to six tasks and where asked in detail about why these tasks were chosen.

Novice One Simulation Interview. As with the majority of the experts, novice one’s simulation interview was based on the fourth grade common core standard. One of the common mistakes she believes newer teachers make is not breaking down steps into small enough pieces. According to this teacher, this occurs when the teacher assumes the students know too much. Often, this is due to a lack of experience.

Table 14

Simulation Interview for Novice 1

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Go back and look at the 3rd grade standard for a starting point	Identify the background knowledge and the way it is worded	decide on a pre-assessment	Experience Sometimes teachers assume too much	Possibly take pre-assessment using technology	Skipping the step
Breaking down the standard	Make sure you cover each step of the standard	Break the standard apart into separate pieces and write it down	Experience Not taking enough time to unpack the standard	Using technology to record lesson plan	Skipping it or skimming this step Not fully covering the standard
Find materials and resources	Decide how you can actually teach it – the logistics	Go through the available resources Find manipulatives	Experience Lessons that didn't work well or assume you have enough materials	Look for virtual manipulatives	Not taking the time to check Assuming too much Not using all available resources

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Decide how we would introduce it	Decide on type of instruction – mini-lesson, whole group, or small group	Look at the allotted time Examine the pre assessment	Foundational block to all lesson planning	This is the best place to incorporate technology Collaborating with coworkers and research	Fear of trying something unknown Deviating from the teacher's edition Asking for help Being too nervous to try it
Decide how you would assess it	To determine if the instruction was effective	Plan out the format of the assessment	This should guide you Determines pace of instruction	Assess using technology – if available	Not using the data that could come from it

Novice Two Simulation Interview. Even though the second novice taught only language arts during the academic year this study took place, he felt comfortable participating in the simulation based on the fourth grade math standard. He has taught math in previous school years. Novice two spoke much about pacing during his simulation interview. This teacher believed being able to accurately gage the amount of time needed to master a concept often comes from experience. He also spoke of the need to differentiate for his students. He also spoke frequently about the need to either make or locate resources.

Table 15

Simulation Interview for Novice 2

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Understand what the standard is	Make sure we are focusing on the main part of the standard	Look at words being used -	Experience and being a critical reading	Type the standard into a Khan Academy Video	Not fully reading the standard – reading it too quickly
Start planning the lesson using stations	Making sure we are giving students to learn, ask questions, and master the standard	Start thinking about videos I could find or record videos myself – look for great apps	From experience I thought I had to create everything but I can find great resources out there	Find or make videos Look at quality apps	Not looking far enough into what they are finding – may not be a quality video
Plan how many station there would be – Teacher would be one of the station, and one would be video, a third station would be an app call Equivalency Tiles on the iPad	Making sure we are giving students beneficial learning experiences Giving enough work to be beneficial without it being too much	Look at math levels of students to create groups (ability levels for some of mixed levels for some standards)	I like for groups to change	Record myself teaching the lesson or use Khan academy video Each station would have 2 to 3 iPads	Timing – how much time should each station make Each group may take a different time – it may need to be differentiated

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Completing an assessment	Going back and looking at what the standard says and making sure the assessment matches the standard	Look at each of the fraction and figure out how many ways they can be decomposed Giving lower groups a scaffolded assessment	Started out teaching as a special education teacher – learned from a teacher I worked with	Take screen shot of the iPad - performance based activity	Not giving the students the right amount of problems Do not give busy work

Novice Three Simulation Interview. Due to only teaching language arts, this teacher did not feel comfortable with the fourth grade math simulation. Instead, she focused her simulation on a reading lesson dealing with inferencing, just as the third expert did. As with the other novices, the third novice teacher frequently discussed the need to locate resources during this interview. Specifically, she mentioned the website Teachers pay Teachers, something no expert mentioned.

Table 16

Simulation Interview for Novice 3

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Unpack the Standard	Trying to understand what the standard is asking	Unpack the standard from the teachers first, then with the students	Helps you know what you are doing and helps the kids know what they are doing	I put the standards into a flipchart and student unpack lesson on the Smartboard	Just reading the standard and expecting the student to understand what it means
Look at Resources	Determine what we have available and find out what we can find	Start looking at specific resources Collaborate with other teachers	Common sense.	Looking on Google, Teachers Pay Teachers Share lesson plans on Oncourse, a digital lesson plan service	Using an unapproved resource – may use something outdated or doesn't meet the grade level standard
Look at the Standards Based Assessment	Look at the language to see what is expected of students	Use the language during an accountable talk Put on word wall	I was told to do this from other teachers Learned from experience	Use a flipchart on the Smartboard during the accountable talk	New teachers don't start with the end in mind

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Break Down the Instruction for the Week	Make sure the standards is taught the way it is supposed to be taught and students are taught what they need to know	Day 1 – unpack the standard Day 2- introduction lesson - start whole group Day 3 – Independent work time Use sentence prompts for keys to look for Day 4 and 5 – Write a response letter	I learned the scaffolding process during my student teaching	Use an online source for students to write with– write 3 things that you could infer Allow them to find articles on line - use a virtual library Have students find passages themselves	Never giving students time to work independently before they are tested
Think about Differentiation	Making sure everybody fully understand - we have many ESOL students	Use differentiated reading passages Pull small groups to monitor to do think-a-louds	Students need this in order to understand	None	May not have lowest group meeting the standard – made the work too easy Wouldn’t look at testing accommodations

Novice Four Simulation Interview. The fourth novice participated in the fourth grade math simulation. As common with the other novices, she focused on acquiring the necessary resources. As with other novices, she discussed Teachers Pay Teachers specifically, something nearly all the novices mentioned but not a single expert suggested. She also spoke much about things she learned in her undergraduate work, something no other expert or novice mentioned.

Table 17

Simulation Interview for Novice 4

Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Model the standard	Show students a pieces of a fraction equal the whole fraction	Use manipulatives – use circles, and then a real world example	Common sense – from experience, maybe from student teaching	Use illuminations for online games on the Smartboard	New teachers would tell them instead of show them New teachers would not show real world examples
Partner activity	Getting a better understanding by having to do it with a partner	Have a scenario for the students as well – there would be two roles – each student would do each role	You will lose students if you go straight to independent – a push in my undergraduate	I would use manipulatives	Letting students pick their own partner
Formative check	Checking for understanding – check to see who understands and who doesn't and what we need to do next	Make the assessment one or two questions and check Pull out students to reteach another way during center time	Learned in undergraduate school Must check your progress	Have students graph their progress on the computer	May not give students immediate feedback

Data Findings

The first cognitive demands table combines data from all of the expert task diagrams, knowledge audits, and simulation interviews. After a careful examination of all of the expert data, the researcher identified the following cognitive tasks as being the most prevalent with the experts during the study. These themes were compared to the themes of the novices to find both similarities and differences between the two groups. By comparing the data from the two groups, identified differences can be used to help determine how to improve non-expert performance in the domain of technology integration.

Table 18

Cognitive Demands Table for Technology Integration Experts

Cognitive Demand	Why Difficult?	Cues and Strategies	Potential Errors
Use Technology to Increase Student and Teacher Collaboration	Novice teachers typically want to teach material and not facilitate learning Novice teachers lack classroom management skills, something needed in cooperative learning Novice teachers are more focused with their performance than the performance of students Novice teachers do not consider the learning styles or differences of students when planning lessons	Allow students to share work with other students through the use of technology Teach students how to give productive feedback for their classmates Use technology as a tool to increase and facilitate classroom discussions Conference with students regularly to check on progress Carefully consider personalities and learning styles of students in addition to academic ability when placing them in groups Allow students to work alone if they would not benefit from working with others Give responsibility of learning to the students	Having students share their work with only the teacher Not using a professional learning community when you need help Not checking in with students until the end of the project Only considering the academic ability of students when placing them in groups Forcing all students to work in groups

Cognitive Demand	Why Difficult?	Cues and Strategies	Potential Errors
		As a teacher, use technology to be part of a professional learning community	
Plan Student Product Prior to Technology Use	Novice teachers think students are properly prepared to use technology with little or no instruction	Storyboard the entire project before using technology Provide rubrics for the students Place charts in the classroom outlining the process for students Have students routinely evaluate where they are in the project	Jumping right into the technology Not giving clear expectations to the students
Plan Each Lesson on the Macro and Micro Level	Novice teachers do not know the curriculum well enough to know the parts where students will struggle Novice teachers typically don’t have enough time to plan for differentiation Novice teachers are not flexible and typically do not change their plans based on student performance	Break down each lesson to the smallest possible skill Use concrete manipulatives to help students when they struggle Be flexible - don’t be afraid to change plans when something isn’t working well Give students step by step directions	Only planning lessons on a large scale Not breaking down lessons into small enough parts Teachers should facilitate student learning and not teach students the standards Novice teachers don’t always take the time to teach vocabulary prior to the lesson

Cognitive Demand	Why Difficult?	Cues and Strategies	Potential Errors
	Due to experience, expert teachers are more successful at gauging the skills of their students Novice teachers do not always have a plan for the entire lesson, instead teaching more day to day	Meet with students often to ensure success Check in with at risk students more often - be proactive as possible with these students Identify the critical transitions points and prepare accordingly Begin lessons by teaching necessary vocabulary	
Model for Students (Including Technology)	Novice teachers are not effective planners Novice teachers are not competent with the curriculum Novice teachers make incorrect assumptions of the technology skills of novices	Practice technology skills in insolation Use pilot projects to learn the technology to be used Break down each part of the lesson to the smallest possible part	Novice teachers do not know their students as well as TIEs and have a difficult time gauging their technology skills
Differentiate Instruction	Novice teachers are more concerned with their performance than the performance of the students Novice teachers don't have enough time to learn the	Careful consider at risk students - have them sit by you during instruction, meet with them more often, and provide scaffolded resources to help them initiate assignments	Not differentiating lessons Not conferencing with students in order to determine their progress Not being patient enough

Cognitive Demand	Why Difficult?	Cues and Strategies	Potential Errors
	curriculum, prepare their lessons, and plan to differentiate their lessons Novice teachers cannot predict where students may struggle- this can be very frustrating for novice teachers	As a teacher, try new teaching strategies, even though they may fail Look for student strengths and consider learning styles	students learn at different rates

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Use Technology to Increase Student and Teacher Collaboration

According the TIEs, the use of technology can increase collaboration in both students and teachers. From the student perspective, the use of technology can help facilitate the learning of students through collaboration, especially when students are systematically placed in small groups. Placing students into cooperative learning groups using criteria other than ability was a stated concern of experts one, two and three. Although most students benefit from working in groups, experts one and three believed a few students will not benefit from working collaboratively and should not be forced to do so.

TIEs are able to use technology to show work examples of students to their classes. The sharing of student work through technology helps increase and facilitate rich classroom discussions. All TIEs interviewed in this study spoke of the importance of planning to use cooperative learning in their lessons and how technology can be used to improve this.

All of the TIEs were unified in placing an emphasis on learning all of the students individually. Expert four suggested regularly taking a class list and jotting down a few personal details of each student to ensure you know them on a personal level.

From the teachers' perspective, teachers can learn a great deal by using technology to participate in a professional learning community (PLC). Both TIEs two and three specifically mentioned this during their interviews; however, all experts in the study were active members in social media in a professional capacity. In fact, experts in this study spoke of how a teacher could easily get a wealth of ideas form other teachers through a single post on social media.

Plan Student Product Prior to Technology Use

TIE one and two both had student planning as an important cognitive task in their thinking processes about planning a technology-rich lesson. Experience has taught them that students can focus just on creating a plan for their work without being hindered with technology. By storyboarding a lesson, students can focus just on creating a plan for their work without being hindered with technology. Including this step in the lesson also helps students stay focused when using technology, something novice teachers indicated could otherwise be a concern.

TIE two suggested giving a rubric to students prior to the start of the lesson. This would ensure students knew all part to include in their work from the onset of the assignment. In addition, TIE two suggested making decisions when planning lessons to outline clear procedures for the assignment. One possible way to accomplish this is by displaying a chart with the procedures in the classroom. She also suggested having students use the chart regularly to evaluate their progress during the assignment. TIE four also liked the idea of using visuals in the classroom. He identified potential pitfalls from his previous teaching experience and created visual aids for the students to use to try to avoid these problems.

Plan Each Lesson on the Macro and Micro Level

Regardless of experience, all participants in this study discussed the importance of macro planning their lessons. In some variation, both the expert and the novice lessons contained a goal, instruction, and a product. However, evidence of novice teachers micro planning their lessons was not mentioned or evident during the study. Some of the novice teachers volunteered this was a weakness in their lesson, especially the modeling of technology. They simply assumed the students would understand the steps and be able to use the technology without additional support. TIEs planned the lesson as a whole, but were also able to break down each lesson into smaller steps. This micro planning also included breaking up the use of technology into smaller steps, something several novice teachers indicated was a struggle for students. TIE one suggested conducting a small pilot lesson for any major lesson using technology as a way for students to learn how to use the technology. She also specifically mentioned the importance of modeling technology in isolation and how novice teachers often skip this step. Expert two suggested making an anchor chart to display in the classroom each required step. This chart could also be used to help the students determine the progress of each student in the assignment. Expert four was absolutely adamant in every interview to break down every part of the lesson into the smallest possible part.

According the TIEs, another important part in micro planning was remaining flexible. Teacher must be able to recognize when students are having difficulties, reevaluate their teaching, and reteach these parts. The TIEs believed these steps are difficult for novices and their teaching is often negatively impacted by this inability.

Model for Their Students (Including Technology)

All teachers participating in this study spoke of the importance of modeling during their lessons. However, only two of the novice teachers discussed the need to model the technology parts of the lesson. Both novice one and two discussed in detail the discreet steps they modeled. Other novice teachers mentioned they were surprised that students had difficulties completing seemingly simple tasks. TIEs discussed the need to model the technology used in their lessons in isolation. Expert four suggested breaking each task into the smallest possible skill. This includes the technology steps, as well. Expert two suggested using student helpers to assist in the modeling of technology.

Use Technology to Differentiate Instruction

Although not specifically stated by each TIE, each TIE seemed to use technology as a way to differentiate instruction. TIEs were able to place students in flexible groups using technology. In addition, some of the experts mentioned technology can be used to present different content for students. Differentiation occurred not just by ability, but also by personalities and learning styles.

The second cognitive demands table includes data from all of the task diagrams, knowledge audits, and simulation interviews from the four novices who participated in this study. The following are the themes that were the most apparent to the researcher. These themes were contrasted with the themes of the TIEs to show how TIEs plan technology-rich lessons differently than novice teachers.

Table 19

Cognitive Demands Table for Novices

Cognitive Demand	Why Difficult?	Cues and Strategies	Potential Errors
Learn the curriculum prior to instruction	Lack of experience Not enough time to learn the curriculum due to other priorities Feel pressure to teach like more experienced colleagues	Unpack the standards with your students Break down the standard into small pieces	Not knowing the standards Not breaking down the standard into small enough pieces for the students Moving too quickly for students
Make judgements about how to teach a lesson	Novice teachers lack experience A lack of confidence from novice teachers Novice teachers do not know what might happen in the classroom, especially with classroom management Novice teachers cannot predict where students will struggle Novice teachers think everything will go according to plan	Determine the background knowledge of the students Estimate how long each part of the lesson will take in order to get an estimate of pacing for the lesson Locate the parts of a lesson where students could struggle and plan for it	Teaching the curriculum incorrectly Not being able to differentiate because of lack of time Have a clear outline of each lesson Not being flexible with problems arise Assume the students already know things they do not

Locate resources for instruction	Lack of experience Very time consuming Novice teachers are still learning the curriculum Locating resources can be time consuming	Find resources on the Internet – especially Teachers Pay Teachers See what resources have been provided by the school district Go to experienced teachers on your team and ask for resources	Finding resources than do not align to the standards Not using manipulatives Not using all available resources
Creating a technology-rich lesson	Novice teachers may get caught up in the technology part of the lesson and may forget about instruction	Monitor students to determine if they become frustrated Use a rubric Create guided questions to help students when conducting research	Save examples to show to future students Teach the logistical parts in isolation

Classroom Management	Lack of experience Difficult to keep all students on task Novice teachers may not be clear enough with their expectations	Have clear routines outlined for students Practice routines so students understand expectations Monitor student behavior closely	Not having clear expectations Waiting until the end of the project until assessing students instead of checking in on students through the whole process Have clear rules when using technology Have additional work for students to do when finished with their project

Learn the Curriculum Prior to Instruction

Although all novice teachers participating in the study had at least one year experience, a commonality identified in the data by them was learning the curriculum prior to instruction. This commonality was not identified during the TIEs interviews.

According to novice one, novice teachers frequently follow the lessons of their more experienced colleagues due to pressure and a lack of confidence. Even when novice teachers have questions about curriculum, they are hesitant in asking for help. In order to alleviate this occurrence, novice one believes experience will help teachers feel more confident to make curricular decisions for themselves.

Having completed two years of teaching, novice two was the most experienced novice teacher in this study. Since novice teachers are not experts in their curriculum, he suggested breaking each part of a lesson into pieces and timing each piece of the lesson in when creating your plan. This would help the novice teacher with pacing during instruction and not get off task. However, the novices three and four said this was difficult because they did not know the curriculum well enough. Again, the pacing of a lesson was not a theme addressed by TIEs.

Make Judgements about how to Teach a Lesson

Citing a lack of experience as the primary reason, novice teachers discussed their inability to accurately predict classroom occurrences when planning technology-rich lessons. This inability meant novice teachers did not know the places in a lesson where students will struggle. Due to this lack of experience, novice teachers were not able to break down lessons into small enough tasks as the TIEs did.

The novice teachers also talked about some of the pitfalls the experts mentioned. For example, novice teachers three and four were surprised by the lack of knowledge of the students when using technology. They did not think they would have to teach the technology steps in isolation. Again, one of the potential problems TIEs mentioned was not having a clear plan. After teaching their lessons, novices three and four realized this was a shortcoming in their lessons.

Locate Resources for Instruction

Locating resources for instruction was a commonality mentioned by all of the novices but only briefly mentioned by the TIEs. The novices agreed that searching on Teachers Pay Teachers and other places on the Internet was a great place to find resources when planning technology-rich lessons. The novice teachers also agreed this was a time intensive part of the planning process and finding already made quality products was worth the savings in time rather than creating a product yourself. During the planning process, TIEs spent more time thinking about how to deliver instruction than locating resources. The decisions they made were based on their experience in the classroom, their knowledge of their students and the standards, and not on resources they found.

There are several possibilities why TIE may not focus on resources to the same extent of novice teachers. First, it is possible that teachers use materials from previous years. For example, TIE two mentioned showing student examples of projects is a great way to introduce a project to students. In order to show a finished project to current students, a project from a previous year may have been used. Secondly, it is possible teachers with more experience make many of their materials. For example, the novice in the study with the most experience, novice three, mentioned making his own materials to post on his blog. This may be a practice also performed by TIEs. Additionally, the TIEs frequently mentioned novice teachers often focus too much on their performance on not on the performance of their students. TIEs spoke of meeting with students frequently, especially at risk students. In other words, according to the TIEs, the priority of novice teachers is improving teacher performance and the priority of TIEs is to improve student performance.

Create a Technology-rich Lesson

When using technology, novices three and four discussed the importance of breaking down each step in the teaching process, especially when using technology, into smaller parts. This was something both of them cited as being a deficiency in their lesson planning. Additionally, these novices were not clear with their expectations of the products students were to create. Novice one discussed how she had to go through the steps of showing students how to attach a file in a message, something she thought would not have been necessary. TIEs in this study talked about the importance of breaking down the teaching of technology into small parts and doing it in isolation but none of the TIEs mentioned being surprised by the students ability (or inability) to use technology for instructional purposes.

The current literature also supports the idea that expert teachers are better able to anticipate the occurrences in a classroom based on experience (Hattie, 2003). This undoubtedly allows TIEs to break down tasks into smaller pieces for students to be more successful. Berliner (2001) believes it takes three to five years for teacher to not be surprised by typical classroom occurrences. All of the novices in this study had less than three years of experience.

Classroom Management

Novices three and four, the novice teachers with the least experience in this study, both spoke of the importance of having good classroom management. During both of their lessons, students were often off task when they should have been working. When asked to reflect on the lesson they chose to discuss during the knowledge audit, both novice teachers cited concerns with keeping students on task, and having clear expectations for both behavior and the assignment. This was a potential issue for novice teachers brought up by the TIEs, especially TIE four.

CHAPTER V

DISCUSSIONS, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

Every domain has experts (Ericsson, 2006). These individuals are the persons whose performance is continually superior to others in their domain. Although some researchers believe expertise can be acquired through inherited traits (Howe et al. 1998), others believe expertise can only be achieved through deliberate practice (Bloom, 1985, Dunn & Shriner, 1999, Ericsson, Roring et al., 2007) and experience (Simon & Chase, 1973). Typically, the acquisition of expertise in most domains requires about ten years of experience (Simon & Chase, 1973), often requiring deliberate practice (Ericsson, Roring et al., 2007). Research has shown that in education, the requirement to gain expertise can occur in about seven years (Berliner, 2001).

Seemingly, a consistent or precise definition of expertise for technology integration experts (TIEs) does not currently exist in the literature. In order to be a TIE, three separate domains must be considered; content knowledge, pedagogy, and technology integration (Mirsha & Kohler 2006).

When examining expert performance, identifying a true expert to study is crucial. Traditional means of identifying expertise, such as observation and peer recommendations, tend to be ineffective (Berliner, 1986, Ericsson, Roring, et al., 2007). Instead, identifying expert performance by using objective means may be the preferred method. In the past, finding experts in educational domains has been difficult because an objective measure of expertise did not exist (Berliner, 2001).

Beginning with 1994, teachers could be certified through a rigorous process where they were evaluated in the domains of content knowledge and pedagogy (Berliner, 2001). Teachers who passed this process became National Board Certified Teachers (NBCT). This provided an independent index for teachers to be rated in the domains of pedagogy and content knowledge.

This chapter will begin with a summary of procedures for this study, followed by a summary the major findings of the study. Next, a discussion of the study will be included, followed by the study's limitations. Recommendations for policy and practice and ideas for additional research will follow. The chapter will conclude with a brief summary of the paper.

Summary of Procedures

This study compared the decision making process of TIEs in planning technology-rich lessons and compared it with the planning of novice teachers. Four TIEs were selected to be compared with four novice teachers.

For the purposes of this study, the establishment of expert status prior to a TIE being included in this study was completed using a three-step process. First, potential TIEs needed to be a NBCT. This ensured the teachers were experts in both pedagogy and content knowledge by an independent source. Teachers satisfying this requirement then needed to show expertise in instructional technology. This was done by using a general expertise questionnaire (see Appendix A) by Van der Heiden (2000) and by submitting a synopsis of an already taught lesson (see Appendix B) to the researcher that the potential participants deemed to be an extraordinary technology-rich lesson. This lesson was scored by the researcher with the use of a rubric (see Appendix C).

To ensure novice status, and to avoid having participants who might be struggling with too many issues of classroom management, novice teachers participating in this study had completed their first year of teaching. None of the teachers had yet completed their third year of teaching. All teachers participating in this study were upper elementary teachers (grades three through six).

The researcher in this study both collected and interpreted the data. Data was checked by participants as a way to ensure accuracy.

This study was conducted using a cognitive task analysis (CTA) framework. CTA allows a wide array of tools to a researcher and is especially effective when studying expertise (Mitello et al., 1997). A specialized, streamlined version of CTA, applied cognitive task analysis (ACTA), was selected to be used in this study. Mitello and Hutton (1998) believe this is the perfect tool for novice researchers to use when conducting a CTA study.

Summary of Major Findings

In order to help replicate outstanding performance through quality professional development, this study focused on the cognitive decisions TIEs made when planning technology-rich lessons. The cognitive decisions of TIEs were compared to the cognitive decisions novices made while planning similar technology-rich lessons. Based on the data obtained from 24 interviews with eight different participants, the following paragraphs are the major findings identified from this study.

TIEs Use Technology to Increase Collaboration

TIEs use technology as a way to increase collaboration, both with students and with their colleagues. Technology use, as planned by TIEs, allows students to learn in an environment of collaboration. A cognitive task identified by the TIEs was planning to use technology to facilitate learning in groups. This cognitive task was not present in the interviews with the novices. After modeling the pertinent part of the lesson, TIEs made decisions during their planning to have students work in collaborative settings. Work examples were used by teachers to show both quality work and work which can be improved. TIEs made a point in their planning of lessons to allow time for student discussion. They believed this was important to help students learn.

Additionally, the TIEs participating in this study all use social media as part of their professional learning community (PLC). None of the novices participating in this study mentioned using technology for this purpose.

Prior to Technology Use, TIEs Have Students Plan Their Project

Prior to using technology in their lessons, the TIEs in this study thought about how students could create a plan for how they intend to use the technology. One manner of planning this use is through storyboarding their project, a suggestion specifically made by two TIEs. This would provide the students with a plan to follow once they begin using the technology. The novices participating in this study did not mention this planning process, however, three of the novices did mention many of the students being off task while using technology during their lessons. Furthermore, the novices in this study mentioned their directions were not clear enough for their students and needed to be improved the next time they have students complete their lesson. TIEs were able to make decisions to avoid these problems based on their teaching experience. Examples of these decisions during planning would include TIEs one and two deciding to have students storyboard their lessons, TIEs one, two and four, modeling the technology in isolation, and TIE four creating prompts to help a few students who would have difficulties initiating the assignment.

These findings are consistent with the current literature. According to Hattie (2003), expert teachers are better able to anticipate where students will have problems during a lesson. Because of this ability, TIEs in this study had students plan their projects prior to using technology, a practice the novice teachers did not consider. This practice allowed the students of the TIEs to be more successful.

TIEs Plan Instruction at the Macro and Micro Levels

As one would expect, and in accordance with their qualifications as experts, TIEs indicate they are better able to plan lessons at both the macro and micro levels than novice teachers. At the macro level, TIEs are able to plan unit lessons over the course of several days or weeks. They were able to examine standards, outline a plan that would address the standards, locate materials, and prepare for planning their entire unit. This also seemed to be the case with novices. However, when it came to micro planning, the TIEs were able to identify the parts of their lesson that students would struggle with. In contrast, during the planning process, novice teachers frequently mentioned the need to learn the content and locate resources. Neither of these commonalities were primary considerations discussed by the TIEs. The novice teachers frequently spoke about how their lessons did not go as planned.

These findings are consistent with the literature. According to Hattie (2003), expert teachers are better able to plan lessons based on their experience. They are able to recognize the parts of a lesson students may struggle and can improvise based on their knowledge and experience.

TIEs Break Instruction into the Smallest Possible Tasks

Closely related to micro planning, TIEs indicated that in their cognitive task sequence of planning, they took mental steps to break down tasks into smaller chunks for students. Each of these small tasks are modeled for students. Regardless of experience, all of the teachers participating in the study discussed the importance of modeling, however, only the TIEs made the choice in planning their lessons to model technology in isolation. The novices discussed how the students were often not as proficient as using the technology as they thought. This oversight was identified as a weakness in the lessons of the novices. Instead of primarily focusing on instruction, novice teachers participating in this study frequently focused on the behavior of their students and the acquisition of resources. These appeared to be automatic tasks for the TIEs. According to Hattie (2003), expert teachers are able to make many cognitive tasks routine through extensive practice. Not requiring mental energy to deal with routine tasks such as classroom behavior and the identification of quality resources allows TIEs to focus on other cognitive tasks such as chunking.

TIEs Use Technology to Differentiate Learning

Finally, TIEs are better able to make decisions on how to use technology as a way to help differentiate learning for their students. All of the TIEs spoke of the need to differentiate lessons for their students based on ability, personality, and learning styles. They had strategies they used for these purposes. Although the novice teachers identified a need to differentiate, they did not have enough time or the knowledge to do so.

Novice Teachers Focus on Locating Resources for Instruction

During the interviews with the novice teachers, the novices focused much of their cognitive attention to locating resources to use for instruction. In particular, novices often spoke of using the website Teachers Pay Teachers when attempting to locate quality resources when planning technology-rich lessons. TIEs rarely spoke of locating resources as a cognitive task during their planning.

Novice Teachers Lack Skill when Creating Technology-rich Lessons

Throughout the interview process, all teachers, regardless of experience, discussed the importance of modeling when planning their lessons. However, the novice teachers did not always know the best way to break down their lessons. Many of the novices incorrectly assumed students would know how to use technology without instruction. The TIEs viewed the breaking down of their lesson into smaller tasks as the most important cognitive task during the planning process.

Novice Teachers Lack Classroom Management Skills

Several of the novices discussed their lack of classroom management skills as a deficiency in their lessons. Students of these teachers were off task when using technology and did not always clearly understand the directions of the assignment. These teachers suggested having clear expectations for the students and the assignment prior to technology use as a way to alleviate this deficiency.

Summary of Findings of Research Questions

1. What is the decision-making process TIEs use when planning to teach technology-rich lessons? TIEs focused their cognitive decisions on how to model both the technology and content part of their lessons. They carefully planned the most difficult parts of their lessons, broke down these most important parts into the smallest possible tasks, and provided instruction by modeling to their students. Additionally, TIEs often planned to have students work in collaborative groups. They also planned in detail hot to create peer groups and in making decisions about hot to select students for membership based on the learning tasks.

2. What is the decision-making process novice teachers use when planning to teach technology-rich lessons? The decision making process novice teachers use often revolves around finding resources and learning the curriculum to teach. The novices participating in this study spoke frequently about how they located appropriate resources to use for their instruction. They also spoke frequently about the need to learn the curriculum prior to teaching their lesson.

3. How do TIEs plan to teach with technology differently than novices? When planning to teach with technology, TIEs focus on the instruction and the needs of the students. The cognitive decisions the TIEs made in this study revolved around pivotal points in the lesson students may struggle, how to teach difficult concepts for students of different abilities, and how to break down lessons into the smallest possible parts. Novices focused more on finding resources and learning the material. In short, the TIEs focused more on the students and the novices focused more on the teacher.

4. When planning to use technology-rich lessons, what mistakes do novice teachers make that TIEs do not? When planning technology-rich lessons, novices frequently assumed students knew how to do things they were not able to do. This oversight may have been rectified by modeling components of technology use in isolation, a cognitive decision often ignored by novices. Additionally, novices often did not consider the classroom management of students during their planning. This oversight seemed to hinder their instruction.

Discussion

The data collected in this study shows decisions TIEs make that novice teachers do not make. These decisions are what set expert performance apart from the performance of novices. Understanding the decisions TIEs make and replicating them could improve the performance of novices. Through guided practice, novice performance could systematically be improved and could ultimately lead to improved student achievement.

When conducting the interviews in this study, especially the knowledge audits, each participant was asked repeatedly how they knew to make the decisions they made. Without question, there were two answers given more than any other; experience and I'm not sure. Simply stated, the TIEs participating in this study could not always explicitly state how or why they made the decisions they did. They just made them, without thinking. Performance with automaticity is at the heart of expertise (Hattie, 2003). Experts do not think, they just do… and what they do is outperform the rest of us based on their experiences (Ericsson, 2006). In order to increase performance, novice teachers must perform routine tasks with more automaticity.

Novice participants in this study gave responses consistent with having a greater cognitive load placed on them than TIEs. Novice teachers frequently discussed the decisions they needed to make in regards to classroom management, learning the curriculum, and locating resources. These were decisions TIEs did not discuss, perhaps because these were tasks performed with automaticity. The cognitive loads placed on the novice teachers to make decisions for these tasks limited their abilities for other cognitive tasks such as planning to model technology in isolation and planning to differentiate instruction (Hattie, 2003). Because TIEs did not seem to have the same cognitive loads placed on them as the novice teachers, they may be able to apply more cognitive attention to conduct these tasks.

During the interviews, the TIEs stated novice teachers are often too focused on their performance and not the performance of the students. TIEs made decisions during the planning of their lessons to identify at risk students and decide on specific instruction to aid their learning. No novice teacher mentioned making the same decisions during planning.

Expert three often referred to having a strong mentoring program for young teachers. She suggested having mentors in the school setting and at the district setting. These mentors should remain consistent for the entire mentoring process. This study shows several characteristics present in technology integration expertise but lacking in novice performance. Working with a mentor over the course of a few years, in the classroom setting, novice teachers could receive individualized, valuable professional development that drastically improves their performance in a short amount of time. In order to accomplish this, the traditional method of afterschool, one size fits all professional development may need to be reexamined by schools. Professional development could be individualized, purposeful, and in context. Findings from this study could be used as a starting place in the professional development for any novice teacher.

Limitations

One of the possible factors limiting this study was the number of TIEs chosen to participate in this study. In CTA studies in other fields, three to five experts is a consistent number of experts to study. However, since no study similar to this one in education was found after an extensive search in the literature, it is unknown interviewing four TIEs is sufficient for this study. Future research in education may show the best number of experts to interview in a study like this one.

Another potential limitation of this study was that no quality instrument was found to help identify expertise on technology integration. Instead, an instrument designed to measure general expertise was used (Van der Heijden, 2000). The creation of a quality instrument to identify technology integration could have greatly assisted the identification on TIEs.

Although the experts participating in this study satisfied the researcher's definition of expertise, other studies could contain different definitions of expertise. Using other definitions of expertise in technology integration would undoubtedly yield different results.

The methodology used for this study, cognitive task analysis (CTA), creates a great deal of data. A total of 24 interviews were conducted during the study, resulting in dozens of hours of data. Although every effort was used in ensuring accuracy during this study, minor errors could have been made in the recording of the data included in this study.

Finally, this study was completed using only one researcher. Replicating this study with additional researchers could provide additional pertinent information.

Recommendations for Policy and Practice

Based on the data collected from this study, the following paragraphs provide a few recommendations in the current policies and practices in schools. First, changes in the identification of experts in education will be discussed. Then, changes in current professional development for both preservice and current teachers will be discussed. Next, the creation of quality instructional videos will be examined. Finally, ideas for changes in college education programs will be discussed.

Currently, the identification of expertise in education is typically conducted through social opinion or observation (Berliner, 1986, Ericsson, Roring et al., 2007). However, Ericsson at al. (2007) caution about identifying expertise in this manner. Instead, a more objective way to identify expertise could and should be used. Individuals identified in this more objective manner could be used to mentor new teachers, provide professional development, serve on district level committees, write common assessments used for school districts, and for many other purposes. Because of the manner in which these experts would be identified, school districts could be confident in the quality of teachers that have been identified for these important tasks.

Following a review of this study, K-12 schools may want to consider rethinking their professional development policies and procedures. Using data collected in this study, the characteristics of expert performance for technology integration have been better established. Characteristics of TIEs identified in this study are using technology to increase student and teacher collaboration, planning student product prior to technology use, planning each lesson on the macro and micro level, modeling for students, and differentiating instruction. Teachers not possessing these characteristics should be provided with professional development, including classroom coaching, as a way to improve their performance. Through classroom observations by administrators, teachers could be placed into groups according to the skills they currently lack. By systematically practicing on deficiencies in their current practice, performance will improve.

A study by Feldon et. al (2010) studied the performance of expert biology teachers creating video lessons for college biology students. These lessons were created using a cognitive task analysis (CTA) framework, much like this study. Students enrolled in classes containing these videos improved their performance from a control group. This study could use as a blueprint to create lessons for K-12 schools. Carefully identifying experts, and learning from their cognitive decisions, such as in this study, would develop expertise. Using a CTA framework, model lessons could be created after identifying the cognitive tasks consistent with expertise. These model lessons could serve a variety of purposes.

First, the model lessons could be useful for professional development for current teachers. The planning of the expert lessons could be broken down into steps, much as the TIEs in this study were asked to do. This could help novice teachers to not miss important cognitive decisions, such as model how to use technology in isolation, that the novices in this study discussed leaving out of their plans. Non-expert teachers could examine these lessons and learn why TIEs make the decisions they do and incorporate it into their lesson planning.

Currently, from websites such as Learnzillion, Khan Academy, and YouTube, a plethora of instruction is available for students on nearly any topic. These websites provide students with instruction anywhere they can get on the Internet. The problem with these sites is that the user is unaware of the qualifications of the individuals making these videos. There is no quality control. However, through careful identification of expertise, this concern could be alleviated. A video series of quality instruction on a broad variety of topics could be created by high quality instructors. Not intended to replace the classroom teacher, these videos could have a variety of uses. First, they could be used as model lessons for preservice teachers and for professional development for current teachers. The decomposition of these lessons would provide a quality blueprint for the creation of new lessons. Second, these lessons could be used for subjects where it is difficult to find quality teachers. For example, if a small school district would like to provide foreign languages to students but is unable to find a quality instructor, these model videos could serve as a substitute. This may be quite helpful in rural school districts or for homebound students. Finally, videos created by quality instructors could be used to differentiate instruction. Due to time constraints in planning, novice teachers in this study did not plan differentiation their lessons. By providing quality lessons already containing differentiated pieces, newer teachers would have some of the planning burden taken off them, allowing them time to learn the curriculum and find other resources, two themes identified by the novice teachers in this study.

Currently, teacher preparation programs focus mostly on learning content knowledge. Later in typical programs, preservice teachers begin to look at theories of pedagogy. Understanding the cognitive decisions TIEs make could be useful in teacher preparation programs. Even before entering the classroom, preservice teachers could learn from the decisions TIEs make when planning lessons. Learning from these decisions could help improve the planning and instruction when these preservice teachers enter the classroom. Preservice teachers could start thinking about more than just content of a lesson; they could start thinking about the importance of their decisions when planning lessons. Examining these cognitive decisions could allow new and young teachers improve their performance.

Recommendations for Future Research

One of the reasons this study is unique to the current literature was because of the objective manner in which TIEs were identified. In order to be a TIE for this study, each participant must have been a NBCT. This qualification ensured teachers were experts in both pedagogy and content knowledge as verified through a rigorous examination by the National Board. Although specific materials exist to help in the identification of technology integration (Mirsha & Koehler, 2006), these tools are designed to only show competency and not expertise. A tool that helps to specifically identify expertise in technology integration, possibly in the same fashion as the NBCT process, should be created. This could only be created after extensive research and may be able to be developed by studying a group of experts as in this study.

The key to this study was the identification of expert teachers and the reconstruction of their outstanding lessons. Although the lessons that were selected by the TIEs in this study were quality, it is possible that going through the methods of this study again with multiple qualified experts at one time could provide an even better model. For example, instead of interviewing upper elementary teachers, a broad category, interviewing only fourth grade math teachers on a specific math standard may prove to be more advantageous. By interviewing a group of very specific teachers on a specific standard should result in a blueprint of a quality lesson few teachers could produce in isolation. Conducing an additional study focusing on this could result in quality lessons that could in turn improve student achievement.

After an extensive search of the literature, no studies using the ACTA methodology to study expertise in education were located. Because the ACTA methodology is designed to study expertise in a streamlined, structured manner for novices, its use in education could prove to be valuable. After careful identification of experts, researchers could use the ACTA methodology to identify cognitive decisions experts routinely make. These cognitive decisions could lead to changes in professional development, preservice education programs, and policy.

Using the ACTA methodology to study expertise in education could help to improve current professional development for current educators. Instead of one size fits all professional development, administrators could learn about the types of cognitive decisions the best teachers make and provide individualized professional development based on their needs. Providing teachers with specific goals and opportunities for guided practice could increase their performance quickly.

Preservice teachers could use the ACTA methodology to interview current expert teachers about the cognitive decisions they make on a daily basis. Current preservice teacher education programs seem to focus primarily on content on not on the cognitive decisions new teachers must make on a daily basis. If preservice teachers could begin to think about these cognitive decisions during their preservice experience, they may be better prepared as they enter the classroom. This could be accomplished through interviewing experts using the ACTA methodology.

Current policies in schools could be changed due to a better understanding of the cognitive decisions being made by subject matter experts. In instructional technology for example, this may mean a different way to procure new hardware and software based on the cognitive decisions of the best experts. These experts may also be interviewed about their thoughts on how to best roll out new technology and the training for staff that accompanies it. These cognitive decisions could be examined by using the ACTA methodology.

Summary

Researchers such as Ericsson (2006) believe expertise is typically earned after about 1,000 hours of guided practice. Not all experiences lead to expertise. One must know what experiences are necessary to achieve expertise.

This study compared the lesson planning of four TIEs to the lesson planning of four novice teachers. Through this comparison, characteristics of expert performance in instructional technology have been identified. If novices were to gain experience specifically in these characteristics, through guided practice, performance could be improved and perhaps lead to expertise.

The findings of this study can be used as a starting point to improve current professional development in preservice programs and for current teachers. By providing future and current educators quality professional development, teacher performance could increase. Ultimately, an increase in student achievement could be the end result.

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APPENDIX A

The Measurement of Professional Expertise: Self-assessment questionnaire (items). Translated English version

1. The Knowledge Dimension

1.1 I have … (very little—a very great deal of) … factual or specialist knowledge in my job domain.

1.2 During that period, I … (never—very often) … introduced ideas or suggestions that resulted in an increase in productivity.

1.3 During that period, I devoted … (very little—a very great deal of) … time to consultations with colleagues outside the organisation who were also working in my job domain.

1.4 I consider myself … (not at all—extremely) … competent to engage in in-depth, specialist, discussions in the domain of my work.

1.5 In situations where I have not achieved my goal and not managed to solve a problem satisfactory, I … (never—very often) … become discouraged. (Reversed scoring for this item.)

1.6 In general, … (very little—a very great deal of) … value is attached to what I say.

1.7 I consider myself … (not at all—extremely) … competent to be of practical assistance to colleagues with factual or specialist questions.

1.8 I consider myself … (not at all—extremely) … competent to provide information regarding my work in a way that is comprehensible.

1.9 During that period, I … (never—very often) … offered to help other people to get hold of the necessary information.

1.10 I consider myself … (not at all—to a considerable degree) … competent to be of practical assistance to colleagues with questions about how to approach the work.

1.11 My array of strategies on how to approach the work would appear to be … (not at all—very often) … out of date, in view of current developments. (Reversed scoring for this item.)

1.12 My superior … (never—very often) … turns to me for advice on factual or specialist questions, which concern my domain of work.

1.13 I am … (not at all—extremely) … up to date with the latest developments in everything that concerns my job.

1.14 In view of current developments, I consider my actual or specialist knowledge to be … (not at all—to a considerable degree) … out of date. (Reversed scoring for this item.)

1.15 I consider myself to be … (not at all—extremely) … competent to utilise colleagues' suggestions and ideas in my work.

1.16 I think that I possess … (very little—a very great deal of) … knowledge that I am able to apply in related areas in new, unfamiliar situations.

1.17 I am … (not at all—extremely) … competent to make prompt decisions with respect to my work.

2. The Meta-Cognitive Knowledge Dimension

2.1 I consider myself to be … (not at all—extremely) … competent to judge who can help me to supplement any deficiencies in my own knowledge.

2.2 In view of the latest developments, I consider myself to be … (not at all—extremely) … competent to judge whether my skills are sufficiently up to date.

2.3 With special reference to that period, I was … (not at all—extremely) … competent to organise my work in terms of fixed targets and deadlines.

2.4 I consider myself … (not at all—extremely) … competent to assess which colleagues (inside and outside the organisation) I should keep in contact with to stay at the forefront of developments in the domain of my work.

2.5 I consider myself … (not at all—extremely) … competent to join in the planning when time estimates need to be made for tasks belonging to my domain of work.

2.6 In situations where there are obstacles or impediments, I … (never—very often) … give up. (Reversed scoring for this item.)
2.7 I consider myself … (not at all—extremely) … competent to indicate when my knowledge is insufficient to perform a certain task or solve a particular problem.
2.8 In general, I am … (not at all—extremely) … competent to distinguish main issues from issues of secondary importance and to set priorities.
2.9 I consider myself … (not at all—extremely) … competent to indicate the causes of any obstacles that may emerge in my work.
2.10 I consider myself … (not at all—extremely) … competent to consider the advantages and disadvantages of particular decisions, which have to do with working methods, materials and techniques in my work domain.
2.11 I consider myself … (not at all—extremely … competent to assess what skills I do not possess when tackling new problems or a new task in my work or in related areas.
2.12 I consider myself … (not at all—extremely) … competent to assess what professional literature I should keep up with to stay up to date for future needs.
2.13 I consider myself … (not at all—extremely) … competent to see the overall picture, even in complex situations.
2.14 I consider myself … (not at all—extremely) … competent to react promptly in situations where I perceive errors, even in situations where there are obstacles and impediments.
2.15 I consider myself … (not at all—extremely) … competent to judge who can be of assistance in helping me to supplement any deficiencies in my skills.

3. The Skills Dimension

3.1 During that period I brought a … (very small—very large) … proportion of my work to a successful conclusion.
3.2 When I have embarked on a difficult task or assignment, I … (never—very often) … give up. (Reversed scoring for this item.)
3.3 During that period I was … (not at all—extremely) … competent to handle the methods, materials and techniques in use in the domain of my work.
3.4 During that period I was, in general, … (not at all—extremely) … competent to perform my work accurately and with few mistakes.
3.5 During that period I was, in general, … (not at all—extremely) … competent to take prompt decisions which had to do with my job.
3.6 With respect to my performance during that period, I consider my work tempo to be … (very low—very high).
3.7 I consider myself … (not at all—extremely) … competent to perform my work even when under great pressure due to a "tight schedule".
3.8 During that period I displayed, in general, … (very little—a very great deal of) … decisiveness in organising my work.
3.9 During that period I was, in general, … (not at all—extremely) … competent to carry out my work independently.
3.10 In terms of quality, my skills are of a … (very low—very high) … level.
3.11 Judging from that period I regard myself as possessing … (no—a very great deal of) … perseverance.
3.12 I consider it likely that I will be able to solve any problems that occur at work with … (very little—a very great deal of) … ease.

4. The Dimension of Social Recognition

4.1 I have … (very little—a very great deal of) … confidence in my capacities that are important to my work
4.2 During that period, I felt … (very uncertain—very certain) … when at work.

4.3 During that period, I produced … (very little—a very great deal of) … work.
4.4 During that period, I functioned as a kind of mentor to … (nobody—five colleagues or more) … helping them to update skills.
4.5 I have a … (very low—very high) … opinion of how well I performed in that period.
4.6 I think that I … (do not at all—to a very considerable degree) … excel in my work in comparison with my colleagues.
4.7 I consider myself … (not at all—extremely) … competent to convince colleagues about my ideas in a convincing manner.
4.8 I think that I am … (not at all—extremely) … competent to introduce ideas or suggestions with respect to my job domain.
4.9 I think that I am … (never—very often) … like a mentor who passes on knowledge.
4.10 During that period I … (never—very often) … introduced ideas or suggestions relevant to my work or related areas.
4.11 I consider myself to be … (very poor—very good) … at my work.
4.12 I have … (very little—a very great deal of) … respect for the work that I produced during that particular period.
4.13 The contribution I made with my work during that period was, in my opinion, of … (very little—a very great deal of) … value to our organisation.
4.14 During that period, I … (never—very often) … acted as a source of information for colleagues.
4.15 I think that through my work I … (do not at all—to a very considerable degree) … help setting a course for our organisation.

5. Dimension of Growth and Flexibility

5.1 I think it is likely that when I introduce ideas or suggestions, I show … (very little—a very great deal of) … originality.
5.2 During that particular period, I was … (never—very often) … actively engaged in investigating areas related to my work to see where success could be achieved.
5.3 In my opinion, I was … (not at all—to a considerable degree) … focused on new challenges as far as my work was concerned.
5.4 During that period, I … (never—very often) … achieved success (a degree of) success in operating in areas related to my domain of work.
5.5 I think it possible that if I did not have all the information I needed, I would feel … (not at all—to a considerable degree) … restricted in my work. (Reversed scoring for this item.)
5.6 During that particular period, I … (never—very often) … concerned myself with the latest developments in the domain of my work.
5.7 I consider myself … (not at all—to a considerable degree) … competent to develop and integrate new knowledge into my work.
5.8 I consider it likely that I am … (not at all—to a considerable degree) … competent to contribute ideas on alternative working methods to compensate for my own deficiencies.
5.9 I consider it likely that I am … (not at all—to a considerable degree) … competent to apply my knowledge flexibly in areas related to my work.
5.10 During that period I … (never—very often) … took initiatives to investigate what sort of work would offer our department new perspectives.
5.11 During that particular period I … (never—very often) … showed that I am able to respond quickly and be alert in taking advantage of opportunities that presented themselves in areas related to my work.
5.12 During that period I had … (very little—a very great deal of) … difficulty in adapting to changing circumstances in the domain of my work. (Reversed scoring for this item.)
5.13 During that period I was … (not at all—to a considerable degree) … competent to perform my work in a creative, transparent manner.
5.14 During that period, I considered myself … (very unambitious—highly ambitious).

5.15 During that period I think that I … (never—very often) … showed that I was searching for renewal and improvements with respect to my work.
5.16 During that particular period I set myself … (very low—very high) … standards for work.
5.17 I think that my present-day knowledge will be of … (very little—a very great deal of) … value in five years' time.
5.18 I consider myself … (not at all—to a considerable degree) … competent to cope flexibly with technological changes.
5.19 During that particular period I … (never—very often) … applied my knowledge in new and unfamiliar situations in areas related to my work with a degree of success.

APPENDIX B

OPEN-ENDED SCREENING QUESTIONS

Think about a time that you planned a great lesson for the classroom using technology. Keeping that lesson in mind, please answer the following questions.

Can you describe your lesson? Please include technology used, how you taught the lesson (methodology), and the subject matter you taught.

What helped you to decide to teach the lesson this way?

How do you know your students learned in this lesson?

Were you able to differentiate your students' learning? If so, how?

How was technology integrated in this lesson?

What made this lesson stand out from your other lessons that had technology integrated?

APPENDIX C

OPEN-ENDED SCREENING QUESTIONS RUBRIC

	expert	prominent	competent	advanced beginner	novice teacher
experience	10+ years	7-10 years	5-7	4-5	0-3
number of events a teacher is able to predict for correctly	teacher is able to successfully predict many events	teacher is able to successfully predict some events	teacher is able to successfully predict a few events	teacher is able to successfully predict a few events	teacher is able to successfully predict no events
student achievement	lesson resulted in growth for nearly all students	lesson resulted in growth for most students	lesson resulted in growth for some students	lesson resulted in growth for few students	lesson resulted in growth for no students
evidence of differentiation	evidence exists of differentiation for many students	evidence exists of differentiation for some students	evidence exists of differentiation for few students	evidence exists of differentiation for no students	evidence exists of differentiation for no students
technology and pedagogy	technology was infused, used by students and allowed learning otherwise not available	technology was infused, used by teacher and allowed learning otherwise not available	technology was used by students or teacher and allowed learning otherwise not available	the same lesson could have been conducted without technology	technology used had no impact on learning

APPENDIX D

TASK DIAGRAM GUIDELINES

Applied Cognitive Task Analysis Interview Guide

TD

Task Diagram. Lists the procedures of a task in a linear fashion.

Preparation Go into this interview knowing which task you want to analyze. You will record the interviewee's responses on a whiteboard or large paper.

Steps

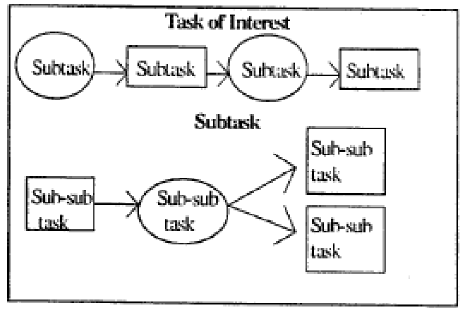
TD-1 Record the **Task of Interest** at the top, center of whiteboard.

TD-2 Ask the interviewee, "Please decompose this task into subtasks. There should be at least three sub-tasks, but no more than six."

TD-3 Record each Subtask from left to right across the whiteboard.

TD-4 Ask the interviewee, "Which subtasks require the most expertise?"

TD-5 Place circles around the tasks that require the most expertise and squares around the rest of the tasks.



TD-6 Record the first **Subtask** that requires expertise on the whiteboard.

TD-7 Ask the interviewee, "Please decompose this subtask into sub-sub tasks. Again, there should be at least three, but no more than six."

TD-8 Record the Sub-sub tasks on the whiteboard.

TD-9 Ask the interviewee, "Which of these sub-sub tasks require the most expertise?"

TD-10 Circle those that require expertise and place squares around the rest.

TD-11 Continue decomposing subtasks until you have a diagram for each one that requires expertise. DO NOT decompose sub-sub tasks.

Application Use this diagram when conducting the **Knowledge Audit** to limit the interview to those tasks that require expertise.

APPENDIX E

TASK DIAGRAM PROCEDURES

Steps	Procedures
TD - 1	Read the following to the interviewee: “Today we will be conducting the task diagram. In the task diagram, we will be examining a time when you had great success integrating the use of technology in your classroom. Specifically, we will be examining the planning of this lesson. We will break the planning of this lesson down into three to six tasks. After identifying the tasks, you will determine which of the tasks was the most challenging cognitive task for you to plan. The information gained in this task analysis will serve as an overview of how you planned this lesson using technology. We will more closely examine the important steps of this process when we conduct the next interview; the knowledge audit.”
TD - 2	Ask the following to the interviewee, “Think about a time when you had great success teaching a lesson that integrated the use of technology. Please decompose the planning of this lesson into tasks. There should be at least three tasks, but no more than six.”
TD - 3	Record each task from left to right.
TD - 4	Ask the following to the interviewee, “Which task required the most expertise?”
TD - 5	Place circles around the tasks that required the most expertise and squares around the rest of the tasks.
TD - 6	Record the task that required expertise.

APPENDIX F

KNOWLEDGE AUDIT GUIDELINES

Applied Cognitive Task Analysis Interview Guide

KA

Knowledge Audit. Contrasts what experts know and novices don't.

Preparation

In the *Task Diagram* you identified the sub- and sub-sub tasks that require the most expertise. Go into this interview knowing the sub-tasks you want to analyze.

Steps

KA-1 Write the **Task of Interest** at top, center of whiteboard. Divide the remaining space into three columns with headings that match the illustration on the right.

Task of interest		
Example	Why Difficult	Cues & Strategies
1. Perceptual Skills *Example of perceptual skills* 2. Anomaly *Example of Anomaly* 3. Past & Future *Example......*		

KA-2 Use the probes listed below to elicit examples of the various aspects of expertise. Record the first **example** in column one. Ask questions KA-3 and KA-4 before moving on to the next probe.

KA-3 For each example, ask, "Why is this task hard for novices or why don't novices know to do that?" Record answers in middle column under the heading **Why Difficult**.

KA-4 For each example, ask, "What cues or strategies do you use in this situation?" Record answers in third column under **Cues and Strategies**.

Expertise	Knowledge Audit Probes
Perceptual Skills	Experts detect cues and patterns and make discriminations that novices can't see. Can you think of any examples here?
Anomaly	Experts can notice when something unusual happens. They can quickly detect deviations. They also notice when something that should happen doesn't. Is this true here? Can you give me an example?
Past & Future	Experts can guess how the current situation arose and they can anticipate how the current situation will evolve. Can you think of any instance in which this happened, either where experts were successful or novices fell short?
Big Picture	If you were watching novices, how would you know that they don't have the big picture?
Tricks of the Trade	Are there tricks of the trade that you use?
Improvising or Noticing Opportunities	Can you recall a situation when you noticed that following the standard procedure wouldn't work? What did you do? Can you think of an example where the procedure would have worked but you saw that you could get more from the situation by taking a different action?
Self-monitoring & Adjustment	Experts notice when their performance is sub-par, and can often figure out WHY that is happening (e.g., high workload, fatigue, boredom, distraction) in order to make adjustments. Can you think of any examples where you did this?
	Optional Probes
Equipment	Unless you're careful, the equipment can mislead you. Novices usually believe whatever the equipment says. Can you think of examples where you had to rely on experience to avoid being fooled by the equipment?
Scenario from Hell	If you were going to give someone a scenario to teach someone humility--that this is a tough job--what would you put into that scenario? Did you ever have an experience that taught you humility in performing this job?

APPENDIX G

KNOWLEDGE AUDIT PROCEDURES

Steps	Procedures
KA - 1	Read the following to the interviewee: "During the task diagram interview, we identified the tasks required when you planned an exemplary lesson integrated with technology. Today, we will be more closely examining the task you identified as requiring the most expertise. In our final interview, you will be given a simulation where you will plan a lesson integrating technology."
KA - 2	Create a chart for the tasks the interviewee identified as needing the most expertise (see Task of Interest template below).
KA - 3	Use the probes listed below to elicit examples of the various aspects of expertise. Record the first example in column one. Ask questions KA-4 and KA-5 before moving on to the next probe.
KA - 4	For each example, ask, "Why is this task hard for novices or why don't novices know to do that?" Record answers in the middle column under the heading Why Difficult.
KA - 5	For each example, ask, "What cues or strategies do you use in this situation?" Record answers in third column under Cues and Strategies.

Expertise	Knowledge Audit Probes - Campoli	Knowledge Audit Probes - Mitello et al.
Perceptual Skills	When planning a lesson, expert teachers can make judgments about how to teach a lesson novice teachers cannot. Can you think of examples where this occurred when planning your lesson?	Experts detect cues and patterns and make discriminations that novices can't see. Can you think of any examples here?
Anomaly	Expert teachers are seldom surprised about what occurs during classroom instruction. When planning this lesson, did you anticipate an occurrence during instruction a novice teacher may not have anticipated?	Experts can notice when something unusual happens They can quickly detect deviations. They also notice when something that should happen doesn't. Is this true here? Can you give an example?
Past and Future	Expert teachers can anticipate where students may have difficulty during a lesson. When planning this lesson, were you able to predict student	Experts can guess how the current situation arose and they can anticipate how the current situation will evolve. Can you

	difficulty where a novice teacher may not have been able to predict?	think of any instance in which this happened, either where experts were successful or novices fell short?
Big Picture	If you were to watch a novice teacher plan a lesson using technology, how would you know that they don't have the big picture?	If you were watching novices, how would you know that they don't have the big picture?
Improvising or Noticing Opportunities	When planning your lesson, could you think of a specific student that you needed to differentiate for because he or she would not have been successful learning in the same way as other students?	Can you recall a situation when you noticed that following the standard procedure wouldn't work? What did you do? Can you think of an example where the procedure would have worked but you saw that you could get more form the situation by taking a different action?
Self-monitoring & Adjustment	Upon completion of teaching this lesson, what did you learn about your performance? Can you think of any changes you may have made to your lesson to improve it?	Experts notice when their performance is sub-par and can often figure out why this is happening (e.g., high workload, fatigue, boredom, distraction) in order to make adjustments. Can you think of any examples where you did this?

Task of Interest			
Area of Expertise	Example	Why Difficult	Cues & Strategies
Perceptual Skills			
Anomaly			
Past & Future			
Big Picture			
Improvising or Noticing Opportunities			
Self-monitoring & Adjustment			

APPENDIX H

SIMULATION INTERVIEW GUIDELINES

Applied Cognitive Task Analysis Interview Guide

SI

Simulation Interview. **Highlights the cognitive elements of a task.**

Preparation Obtain a simulation of the task. The simulation does not have to be high fidelity; it can be a paper and pencil simulation, video, or whatever is available.

SI-1 Ask the SME, "Please review the simulation keeping in mind that I will be asking you about the decisions and judgments you would have made in this situation." Offer the SME pencil and paper on which to keep notes.

SI-2 Divide a whiteboard into 6 columns with headings that match the illustration on the right.

Events Decisions Judgments	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Event #1					
Event #2					
Event #3					

SI-3 After the SME has reviewed the simulation, ask: "Think back over the scenario. Please list the major events/judgments/decision points that occurred during the incident. As you name them, I am going to list them in the left column on the board."

SI-4 For each event in the left column, ask the questions listed below. Ask all five questions about a specific event before moving on to the next event. Record the answers to each question in the appropriate column.

- **Situation Assessment** What do you think is going on here? What is your assessment of the situation at this point in time?
- **Actions** What actions, if any, would you take at this point in time?
- **Critical Cues** What pieces of information led you to this situation assessment/action?
- **Alternatives** Are there any alternative ways you could interpret this situation? Are there any alternative courses of action that you would consider at this point?
- **Potential Errors** What errors would an inexperienced person be likely to make? Are there cues they would miss?

APPENDIX I

SIMULATION INTERVIEW PROCEDURES

Simulation Interview

Your principal comes to you one day and asks you to mentor a new teacher. As part of the process, your principal gives you a math standard and wants you to show the new teacher how you would plan a lesson using technology. I will ask you questions about how you would plan this lesson and why you are making certain decisions.

CCSS.MATH.CONTENT.4.NF.B.3.B

Decompose a fraction into a sum of fractions with the same denominator in more than one way, recording each decomposition by an equation. Justify decompositions, e.g., by using a visual fraction model. *Examples: 3/8 = 1/8 + 1/8 + 1/8 ; 3/8 = 1/8 + 2/8 ; 2 1/8 = 1 + 1 + 1/8 = 8/8 + 8/8 + 1/8*.

Steps	Procedures
SI - 1	Read the following to the interviewee, "During the knowledge audit, we closely examined the tasks you identified as requiring the most expertise when you plan a lesson using technology. Today, you will be asked to discuss how you would handle creating a lesson in a simulated scenario."
SI - 2	Ask the interview, "Please review the standard and simulation keeping in mind that I will be asking you about the decisions and judgments you would have made in this situation."
SI - 3	After the interviewee has reviewed the standard and the simulation, ask: "Think back over the scenario. Please list the major steps you would take to plan this lesson while integrating technology. As you name them, I will make note so we can examine each step in more detail."
SI - 4	Place each event in the first column of the chart. Ask all five questions about a specific event before moving on to the next event. Record the answers to each question in the appropriate column.

	Simulation Interview Probes - Campoli	Simulation Interview - Mitello et al.
Situation Assessment	What are you trying to accomplish in this step? Why is this an important step in your planning process?	What do you think is going on here? What is your assessment of this situation at this point in time?
Actions	What actions, if any, would you take at this point?	What actions, if any, would take at this point in time?
Critical Cues	How did you know that you needed this step in order to plan this lesson?	What piece of information led you to this situation assessment/action?
Alternatives	Can you think of another way you may be able to incorporate technology into this lesson?	Are there any alternative ways you could interpret this situation? Are there any alternative courses of action that you would consider at this point?
Potential Errors	What mistakes would an inexperienced teacher make when planning this lesson? Can you think of any ways an inexperienced teacher may not integrate technology during this lesson in an effective manner?	What errors would an inexperienced person be likely to make? Are there any cues they would miss?

Simulation Interview					
Steps	Situation Assessment	Actions	Critical Cues	Alternatives	Potential Errors
Step #1					
Step #2					
Step #3					
Step #4					

APPENDIX J

COGNITIVE DEMANDS TABLE

Cognitive Demand	Why Difficult?	Cues	Strategies	Potential Errors